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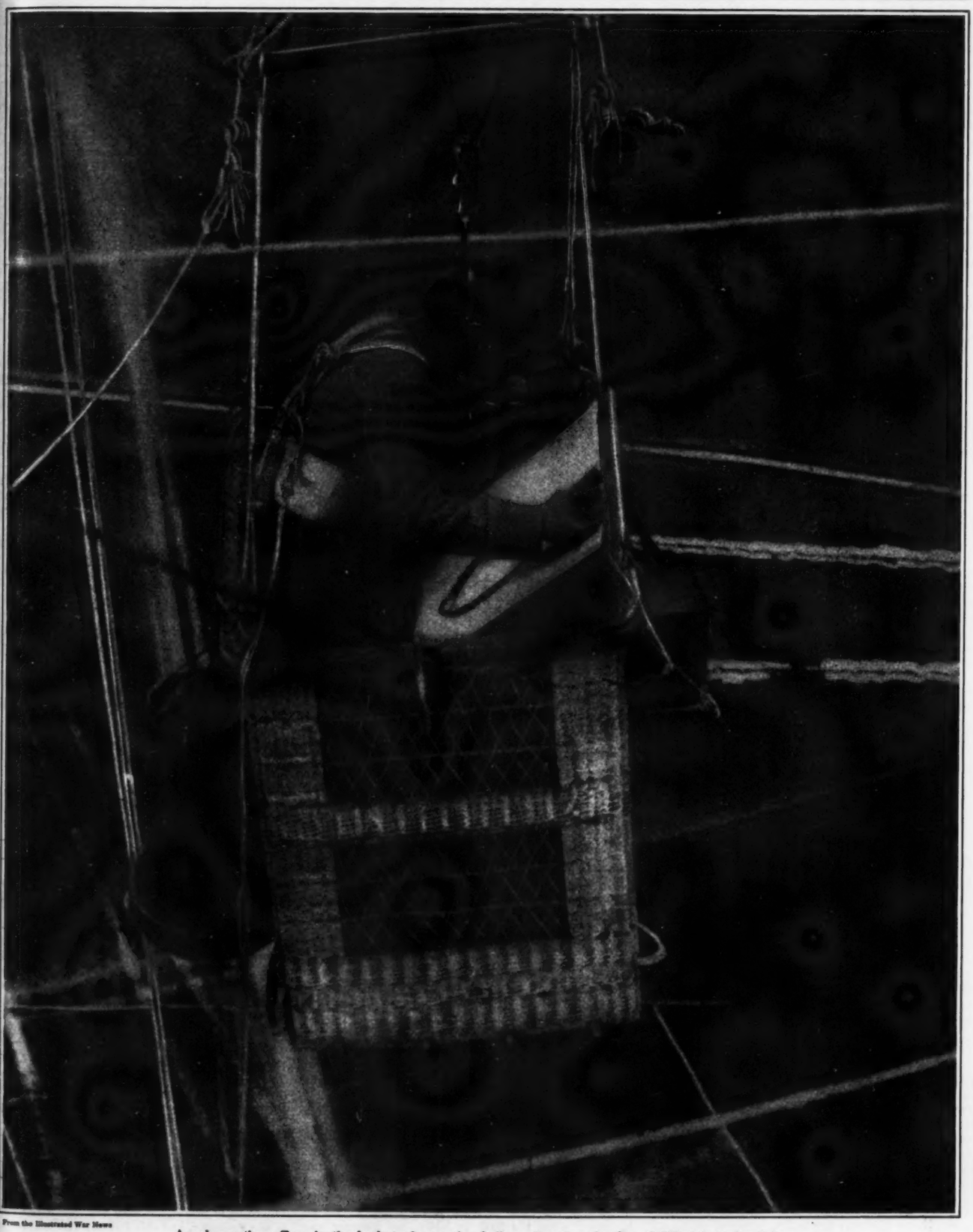


From the Illustrated War News

An observation officer in the basket of a captive balloon directing the fire of Allied batteries below

OBSERVATION BALLOONS AND ARTILLERY FIRE [See page 150]

Industrial Applications of Electrons*

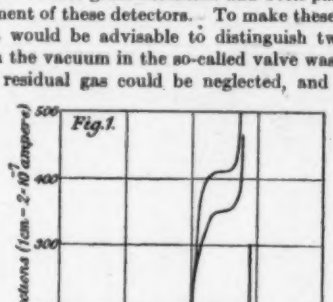
Some Uses That Could be Made of Their Products

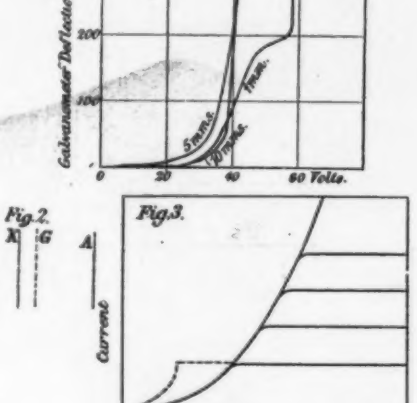
By Sir J. J. Thomson, O.M., P.R.S.

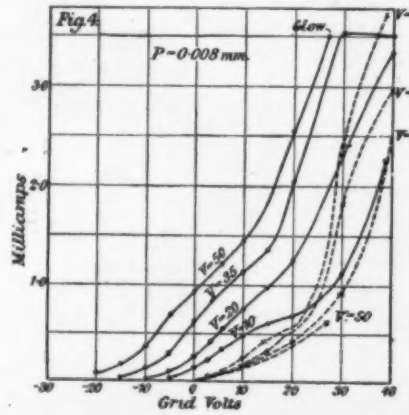
THE Friday afternoon discourses of the Royal Institution were closed for this season by Sir J. J. Thomson O.M., P.R.S., who lectured on "Industrial Applications of Electrons." If there were any members present said Sir Joseph in introducing his discourse, who had listened to the first announcement, made by him 20 years ago, in the same place, of the discovery of electrons, they would admit that they would have been very skeptical if they had been told that after 20 years they would listen to another discourse on commercial applications of those electrons. The electrons had been described as particles of negative electricity, so small that 1,700 of them would only make up a hydrogen molecule, and moving at such a rate that they would only exist for the hundred-millionth of a second in a discharge tube. Such properties appeared rather of a transcendental character and not promising from a practical point of view. But, as a matter of fact, electrons were now in trade catalogues.

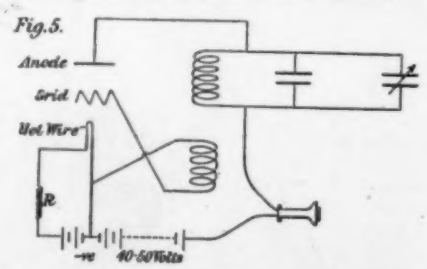
The electrons had properties which were important if they could be utilized. Inventors would give a great deal for a body of no mass, provided the possibility of its being acted upon by forces did not vanish together with the mass; in the common case of the horse and the hay, the one could not be sustained without the other. From that point of view the electrons were of great possibilities. In the second instance, the electrons lived only for a very short period, and were independent of what had happened before and might happen afterwards. Thus they gave really instantaneous photographs, not like pointers and dials for averages of seconds but for a very small fraction of a second, and they were hence of great value for measurements of the forces of electric waves which were changing their directions many times a second. For particles existing only for 1/100,000,000 second the periods of electric waves were almost an eternity, and the particles would register such periodical forces as if they were steady. Advantage of this property was taken in several applications. The registration was effected by allowing the particles to impinge upon a screen of some platinocyanide, *e. g.*, when the eletric force to be measured acted upon the stream of particles passing through the field of force, the light spot was deflected. To demonstrate this effect Sir Joseph had two wire coils, "A" and "B," placed near one another in the same plane; an alternating current sent through "A" induced another current in "B." The magnetic fields produced were at right angles to each other, and if combined the resultant field direction would bisect the right angles; if the two currents further differed in phase, the resultant field would describe an ellipse.

The stream or column of cathode rays could also be used, Professor Thomson thought, for registering continuous electric waves. Let the stream pass through the electric field of two plates and connect these plates to an antenna or a transformer. As long as no wave was coming on, the stream would flow along steadily; when the waves came, the spot would be drawn out into a straight line. If the waves were continuous, the illumination along that line would be uniform; if the waves were cut up into dots and dashes, the dashes would show quiescent bright spots of longer duration than the dots. There were other ways of registering the arrival of electric waves by electrons, and tens of thousands of such apparatus were already probably in use. In these apparatus a stream of electrons was liberated by heating a wire of tungsten or a strip of platinum coated with lime; the particles were emitted at low speeds, but could be accelerated by the use of electric fields. The curves illustrating for a hot-wire cathode and any anode the relation between the current and electromotive force had been determined years ago in the Cavendish laboratory, and they were of a peculiar kind. The current increased with the voltage, but (Fig. 1) then bent off flatly, so that for a time increase of voltage had no effect on the current. Starting from high volts, this meant that, when the volts were reduced below a certain value, the current fell off tremendously. When the external voltage was subjected to the action of electric waves, therefore, the positive phase of the message would not affect the current, but the negative phase would, and a small change could not increase the current. but could only diminish it. If then the message were cut up into dots and dashes, the detection of the signals was facilitated, and that had been applied by Professor Fleming in the early days to detect radiotelegraphic messages. Of late great attention had been paid to the improvement of these detectors. To make these matters clearer it would be advisable to distinguish two cases: (1) When the vacuum in the so-called valve was so good that the residual gas could be neglected, and the discharge was purely electronic; (2) When some gas was present. The first case of purely electronic discharge had been especially decided by Langmuir with the aid of the remarkable mercury condensation pumps which were described in *Engineering* January 26th last; Sir Joseph himself made use of the glass pump which was illustrated in Fig. 4 on page 83 of that issue. The gas to be withdrawn, he explained, met the rush, at 100 m. per second, of mercury vapor which was being condensed on the cooled walls and which carried the gas down for removal by the rough pump. Sir Joseph's own pump reduced the gas pressure from 0.5 mm. of mercury in 1½ minutes to so low a degree that the electric discharge would no longer pass. The one trouble of this pump, the lecturer said, was that it relied so much on the rough pump; to attain the realisable marvelous rapidity of working the back pressure of his pump should be ½ mm.; when the flask in which the mercury was boiled was bigger and the flame hotter, one could work with back pressures of 0.5 mm. and even 1 mm.









Supposing now they had obtained the high vacuum necessary for purely electronic discharge, the relation between current and potential then became very interesting. It was usual in these experiments to work with three electrodes, a cathode K, a grid, G, of bent wire, or a perforated plate in front of K, and an anode A, somewhat as in the diagram, Fig. 2. As long as the cathode K was cold, the current followed the main curve in Fig. 3 up to a certain point, and then turned off flat in a horizontal line; when the cathode was hot, the curve proceeded to a point higher up before it turned off. In other words, when the cathode was cold, the potential was practically the deciding factor; when the cathode was hot, the temperature decided everything. The curve hence ascended, then turned flat, and any electric waves falling on it would diminish the current; the sensitiveness of the device to waves depended upon the steepness of the curve, and to increase the steepness a little gas was admitted; thus case (2) arose.

The cathode emitted electrons, which were driven over to A (Fig. 2) by the external potential, but might also accumulate on and near the grid; their repulsion would then counterbalance the attraction from A, and the particles would be driven back into K and thus stop the further emission of particles, Under those conditions the highest point reached in the curve would depend upon the potential applied. But it was possible to increase the steepness of the curve. When a little gas was admitted between A and G, a few positive ions would be produced, and they would move slowly (being more massive than the electrons) and remain almost stationary, neutralising some of the electrons near the grid, through the perforations of which they could pass; the grid must not be too close for this reason. The effect was therefore that more electrons could be emitted by K, and the current curved (in the dotted line of Fig. 3) and bent off more sharply than before. The suitable potential relation was given by the equation: grid potential/anode potential $n^2m/4M$, where n was the number of positive ions produced per electron m the mass of an electron, and the M mass of a positive ion. With this arrangement the grid might even be negative to the cathode; the grid would still facilitate the further emission of electrons, provided the lines of force could pass through the perforations; Fig. 4 shows the curves obtained with external potentials up to + 50 volts and grid potentials ranging from — 20 to + 40 volts. Another method of obtaining high sensitiveness was to work at higher gas pressure with the help of ionization; when the gas was ionized the current rose at tremendous rapidity. In that case the condition for the most sensitive state was:

$$\frac{\delta i}{i} = \frac{1}{1.8}\frac{\delta E}{Q},$$

where i was the current, δi the change in the current, and δE the change in the grid potential. Those devices were, however, subject to the one drawback that with intense ionization, which would become apparent by the bluish glow, the ions struck the glowing tungsten wire, and that was fatal to the wire.

All these devices served for the registration of small changes in currents received. But electrons could also, in so-called heterodyne apparatus, be utilized for producing continuous electric waves. The idea was that of the pendulum clock and escapement. The pendulum oscillated at a definite rate, but without the aid of the escapement the oscillations would die away. One of the ways in which continuous waves could be produced was indicated in Fig. 5; the condenser and anode circuit correspond to the pendulum, the circuit of the battery, grid and hot wire to the escapement. This arrangement was now largely used. Suppose the waves received were of 50,000 periods, the waves imposed upon them were of nearly the same period, say, 49,000 periods, and the resulting waves represented the difference, waves of 1,000 periods. An acoustical analogue would be formed by two bird calls, each too high to be heard, but not of the same frequency; the ear should be able to hear the beats when the two notes were sounded together. Such an experiment not being suitable for a lecture room, Sir Joseph had combined two whistles, shrill, but just audible, with a resonator tuned to the difference in period. A soap film closed the the mouth of the resonator, and this film reflected a beam of light; the image of the vibrating film was to be thrown on the screen.

*Engineering.

Cultivating Wild Flowers

How to Make Beautiful Gardens that are Different

By Delia W. Marble

Most of our early spring wild flowers grow in the woods and prefer shady places, although some kinds will thrive and even grow larger in an open border if the soil is fairly moist and cool.

It should be kept in mind that wood plants require an acid soil or leaf mold or peat, and should be mulched with leaves. They do not like barnyard manure, lime, or fertilizer. Get leaf mold from the woods, mix it with earth shaken out of sods or from old fence corners. Wherever you want to set your plants dig out a hollow a foot or more in depth according to the size of the plant, and fill it with leaf mold; or a larger bed may be dug out to a depth of two or three feet and filled in with a mixture of leaf mold, peat, and some sand. At the same time start a compost heap for future use of sods and leaves—oak leaves are best—and muck from a swamp. In a year or two this will be in a good condition to use.

Instead of attempting to transplant flowers from the woods, it is safer and easier to buy them from a dealer, especially if you intend planting in masses. The nurserymen who specialize in native plants can furnish most of the kinds mentioned in this paper.

Our earliest spring flower is Liver-leaf, a hardy little friend which will thrive in an ordinary garden bed as well as in the shade, and if taken into the house in a flower pot in winter, can be forced for early blooming. It makes fine clumps, and after the delicate violet blossoms are gone the red-brown leaves are handsome all summer. At about the same time comes the bloodroot, with a single pure white flower and attractive leaves. This will grow in rich soil in either sun or shade. Dutchman's-breeches, a small relative of the bleeding-heart, is especially charming, with quaint white flowers and feathery foliage that soon disappears. It requires shade like the anemone, the most fragile of wild things.

Adder's-tongue lily has yellow bells and pretty spotted leaves, and spreads readily. This would do well in a lily bed. The bulbs must be planted deep, as every one who has tried to dig them up knows. Spring-beauty is a white flower, veined with pink, that makes a solid mat and is excellent to fill in with. The delicate sprays of mitrewort and the bellworts belong in the same woodland places along with foam-flower and the little smilacina. Wild ginger should be planted in some shady nook for the pleasure of finding its brown blossoms close to the ground in early spring. Rock saxifrage will grow anywhere, even in the crevices of rocks, and is one of the earliest of the spring flowers.

For trailing arbutus or mayflower, Mr. Edward Gillett's directions are: "Select a shady spot where there is perfect drainage, a dry sandy soil is preferable, cover the plants with about an inch of leaves or enough to keep the ground cool and moist, and let them remain for a whole season, as it takes that time to get the arbutus well established." One difficulty with arbutus is that it depends upon mycorrhiza or fungous growth on its roots requiring special soil conditions. This accounts for many failures. However, in the Department of Agriculture in Washington, Mr. Coville has succeeded in raising both arbutus and blueberries, which belong to the same family, in pots by adding phosphoric and other acid ingredients to the soil. They seem to like sour food, so keep barnyard manure away from your arbutus bed, and mulch with leaves.

Partridge-berry is a creeping evergreen vine with white blossoms and red berries that last all winter. Shin-leaf is often called wild lily-of-the-valley on account of its fragrance; princess'-pine has evergreen leaves and interesting white flowers, and rattlesnake plantain is a familiar orchid with mottled leaves.

In damp, rich soil under trees or shrubs there is a beautiful group of plants of medium height to use. Jack-in-the-pulpit, beloved of all children, wake robins, both our common kind with red-brown flowers and the white one called wood lily; ginseng, Solomon's seal and false Solomon's seal go in this company. The blue-berried cohosh loves the same kind of a place, though it will grow in the open too; also the baneberry and the snake-root, called sheeptail from its spikes of white flowers. This last is seen at its best against a background of green on the edge of woods or shrubberies.

*Republished from the *Journal of the N. Y. Botanical Garden.*

Those who are fortunate enough to have near their gardens a brook or grassy-edged pool might plant marsh marigold, commonly known as cowslip, though it isn't a cowslip at all. Its glistening yellow flowers make wet places gay in early spring. The pale pink cuckoo-flower will love the edge of the pool, and white hellebore, one of the most decorative of plants with its clasping leaves that look as though they had been ironed in plaits, also likes the wet places. It grows three or four feet tall and has a panicle of greenish flowers. In shallow water the pickerel-weed, with spikes of blue, may be grown, arrowhead with white flowers and arrow-shaped leaves, and golden-club. Near the edge, where the ground is wet, put grass-of-Parnassus, which lifts its white flowers well above the leaves in August. Plant jewel-weed under an overhanging bush, cardinal-flower where it can see its reflection in the stream, and with cat-tails and rushes in the background, honey-balls to bring butterflies, and the stately royal-fern dipping its fronds in the water your pool will be a joy all summer.

Our native orchids are a beautiful group of plants, some of them difficult to cultivate, but all worth trying. Of the woodland species requiring leaf mold and shade, the handsomest is the pink ladies' slipper, which grows wild under pine trees. Wherever you see it standing up and nodding its pink head, it gives you a thrill of delight. The yellow ladies' slipper or moccasin-flower is not less beautiful. A rhododendron bed would be an ideal situation for any of this group of orchids, as it is for lilies and for plants of the heath family. The lavender and white showy-orchis is found early in wet woods, and there are a number of others, all interesting though less conspicuous. In meadows and in sphagnum bogs we find calopogon with lovely mauve flowers on a slender stalk, and rose pogonia, shell pink, with the fragrance of violets. Other meadow orchids are the purple-fringed orchis, the green-fringed orchis, and the common white ladies-tresses. It is not worth while to transplant the wild ground orchids, since many will die if you do, and all can be had from the dealers.

Quite different from running brook or wet meadow is a sphagnum bog, where the water stands and the Sphagnum is like a wet sponge under your feet. For those who have the right place and time for an experiment, a miniature bog garden is full of interest. Choose a low spot which you can conveniently flood when necessary, dig it out until you come to hard-pan, or if there is no hard-pan put in blue clay and pound it down. Make a cement edge to hold the water, but do not let it show. Put in some muck from a swamp to start with. Then go to a sphagnum bog and dig up the moss, digging deep to get earth below the roots, and bring the chunks home carefully and plant them. You will find all sorts of lovely things among the moss—wild cranberry, pitcher plants and ladies' slippers—and you can add others. The real bog should have sheep-laurel growing around it, and little tamarack trees and tall blue-berries. I do not know why such a bog should not favor mosquitoes, but as a matter of experience I have not found them troublesome in the wild sphagnum bogs that I know.

In midsummer the tall meadow-rue should be in our gardens. Its delicate sprays of white flowers sway in the winds with the meadow grasses, and I know of nothing else with quite its exquisite grace. Another splendid garden plant is the cow-parsnip. It is six feet high, has large flat clusters of white flowers and handsome great leaves, and is one of the most architectural of plants. It grows usually along the margins of streams, but takes kindly to any deep rich soil, as the swamp-mallow does. Along with meadow-rue, we find wild lilies, both the erect meadow-lily and the nodding one. These are easily grown and can be had of all dealers.

The cardinal-flower is deservedly a favorite and will grow in a garden border. Like many perennials it needs occasional transplanting to fresh soil, or starting afresh from seed. In handling this and other meadow flowers, remember that they probably increase by suckering from the roots. There is still a great deal to be learned about the needs of the wild flowers and a certain flavor of adventure in attempting to cultivate them. Each species is likely to develop peculiarities of its own which are nowhere recorded.

For sun or shade, open ground or rocks, the wild columbine is always good. I saw it once where it had grown three or four feet tall, showing what favorable conditions would do for it.

Another attractive red and yellow flower, but difficult to transplant because it is parasitic on the roots of grasses, is the painted-cup. It should be cherished where it occurs. Blue flag also should be encouraged in the meadows for the lovely sheet of color it makes, though in gardens the cultivated kinds are better. Blue lobelia is a valuable garden plant. Mulleins have their uses and the little moth-mullein is charming. The large, fragrant thistle, and the beard-tongue cannot be passed by. Yellow meadow-parsnip, wild geranium or cranesbill, and alum-root are easily grown in the garden, and so is the little innocence or Quaker-lady.

The despised roadside weeds, bouncing-bet and butter-and-eggs are really garden outlaws, banished because they grow too rankly and crowd out better things, but they might well be used to fill in waste corners. A good group of summer plants for the edges of shrubberies includes the celandine poppy, pearly-everlasting, flowering-spurge, and live-forever. For covering banks there are two little creeping vines, money-penny or creeping Jenny with yellow flowers, and gill-over-the-ground, with purplish-blue ones. The latter planted under lilac bushes will grow in a thick mat and blossom at the same time as the lilacs.

In June and July our gardens are full of bloom, but with August comes a slack season in the perennial border, and it is just here that the wild flowers would be a help, for August is one of their most gorgeous months. In untouched swamps Joe-Pye weed makes wonderful masses of deep old rose, boneset supplies the white, iron-weed a dull purple, and the slender spikes of blue vervain the blue color, while the graceful wild sunflower furnishes the yellow. This sumptuous contrast of color lasts for a month and might well be transferred to deep moist soil in or near the garden. Along with the Joe-Pye weed and of the same color is the swamp milkweed with its flat-topped cluster of flowers. It is easily grown and is a lovely bit of color. The butterfly-weed is also easily grown and is fine wherever its flaming orange does not clash with the milder things.

Purple asters are among the most valuable of our native plants for naturalizing. Coming as they do late in the season, in every shade from the dark purple of the New England aster to pale lilacs and whites, nothing could be better than masses of them wherever a space can be found. They grow with astonishing luxuriance in a good garden. I have seen them six feet tall and covered with blossoms. There are many varieties and all are beautiful.

Fringed gentian, the latest of the wild flowers, is an annual and can be raised from seed. The field and roadside plants, unlike the woodland flowers, thrive in an ordinary well-manured garden soil and improve with cultivation.

Of our wild vines, the best are, the wild grape, which has beautiful leaves and deliciously fragrant flowers. Clematis, or virgins'-bower, is like *C. paniculata*, but comes earlier. Woodbine is always delightful for color in the autumn. Bittersweet has good foliage and orange and scarlet berries. Cat-brier is valuable for its green stems in winter, but do not plant it where you expect to walk, its claws are long and sharp. The ground-nut has chocolate colored blossoms with the fragrance of violets. Nightshade is a pretty slender vine with purple blossoms and red berries.

A different and delightful way of using wild flowers is to keep and improve the wild gardens that nature has made, and here I want to make a plea for preserving flowers in their native places. They have two foes, the children and their elders who ruthlessly pick and pull up all the flowers in sight, and the farmer who calls them all weeds without discrimination.

When I was a child our roadsides were blue with fringed gentian. Now you may travel miles without seeing one. People say "I left the roots!" But gentians are annuals and the roots are no more use than the roots of China asters after the flowers are gone. Even perennials like columbine need to be renewed by seed. Our hillsides used to be pink with azaleas. Now there are hardly any in sight from the main roads.

His Majesty, "John Kerr."—Since his desperate encounter with "Black Dog" last September in which he badly worsted his antagonis , this powerful five-year-old buffalo has been absolu e monarch over a realm of eight thousand acres and a herd of eighty-two buffaloes

The eight-thousand-acre buffalo pasture in Wichita National Fores: and Game Preserve—with part of the herd coming to be fed (photograph made in January). The woven-wire fence, six feet high and sixteen miles long, is heightened by two wires above and supported by oak or steel posts

People break off the whole top each year until the poor plant is discouraged. There is still plenty of laurel, though you have to go to out-of-the-way or protected places to find full-sized bushes; but with the cutting of it summer and winter for decoration I fear the end is in sight. This is not an idle fear; already laurel is reft from the Pocono and Delaware Water Gap where once it covered mountain sides, trailing arbutus has almost disappeared from Lakewood and everywhere is the same reckless destruction of natural beauty. This has been a wonderful year for dogwood; consequently one meets motors so filled with the lovely white branches that the occupants are hardly visible. Not reasonable quantities which might be picked without harming the trees, but branches of five years' growth broken off, only to wilt in a few days.

Few gardens are more lovely than certain meadows; one in June is pink with calopogon and pogonia; others are full of lilies asking only to be let alone and mowed late—while we are toiling over lily beds somewhere else! The swamps, brilliant with late summer flowers, would be a triumph for any gardener.

I would suggest that where money is being spent on beautifying one part of an estate, a little might be diverted to preserve the beauty which already exists. Why not fence in any special attractive spot, and have a gate and seats? then it would be a part of the garden plan, no longer careless farming but well considered landscape gardening. Such little reservations would be a source of quite unexpected pleasure to your friends.

There are still wonderful thickets near the roads and many beautiful banks of ferns. I wish that more property owners would consider and protect such places. They add more than we perhaps quite realize to the charm of the country.

Contributions to Water Analysis

Standard Caustic Soda Solutions. To prevent standard solutions of caustic soda from undergoing change, the solution should be made up with one-third of its volume of glycerol. *Hardness.* The modern method of ascertaining the hardness of a water is to determine the alkalinity, and to subtract the "carbonate" hardness calculated from this, from the total hardness. For these results, the terms "carbonate" hardness and "remaining" hardness should be used, and the terms "temporary" and "permanent" hardness reserved for the results of the soap test. The reason for this is that the two methods give different results for the same water. *Determination of bromine.* The residue from a liter of the water is distilled after oxidation with permanganate in presence of manganous sulphate, and the bromine in the distillate titrated with arsenious acid. *Determination of Iodine.* The residue from a liter of the water evaporated with caustic soda is ignited and dissolved, the solution acidulated and shaken with carbon tetrachloride. the depth of the color produced is proportional to the amount of iodine present. *Determination of arsenic.* 100 cc. of the water, or one liter concentrated to 100 cc., is introduced into a flask with zinc and sulphuric acid, the neck plugged with cotton-wool soaked in lead solution, and the mouth of the flask tied over with white linen moistened with gold chloride solution. The reddish-blue color produced is proportional to the amount of arsenic present. *Mineral analysis.* The results of a complete mineral analysis should be checked by dividing the weights of each anion and cation found by its equivalent; the resulting quotients for the anions are added, together, also for the cations; the two sums should equal one another.—Note in *J. Soc. Chem. Ind.* on an article by L. W. WINKLER in *Z. agnew Chem.*

A Buffalo Bullfight*

By Ed. D. Crabb, Formerly of the United States Forest Service

This fight occurred in the Wichita National Forest and Game Preserve, near Cache, Oklahoma, in September, 1916. There are 61,630 acres in this forest and game preserve. Of this number of acres there is an enclosure of eight thousand acres constituting the so-called "buffalo pasture." The fence, of heavy woven wire, around this pasture is about six feet high with two heavy wires above it, and is supported by large oak or round steel posts. This fence is sixteen miles long, and encloses mountains and flats, timber and prairie, as well as some beautiful stretches of creeks that afford an ample supply of sparkling cold water. The native grasses form the richest and most luxuriant pasturage that Oklahoma affords.

During the breeding season most of the buffalo bulls are segregated from the herd[1] in a two-hundred-acre bull pasture, and here are staged some great free-for-all fights. On one occasion during a fight nearly a quarter of a mile of woven wire fence was torn down, not even one of the steel posts remaining upright after the bulls were finally separated. It was in this pasture that the younger bulls of the herd killed "Quanah Parker," a twelve-year-old bison shipped here from the New York Zoölogical Park and named in honor of the late chieftain.—ED. D. CRABB.

The large, surly, nine-year-old buffalo bull, "Black Dog," was turned into the field with the herd one morning late in September, and when he was a short distance from the herd another bull, named "Comanche," challenged him to a fight. After but a few short, sharp rounds, however, "Comanche" agreed to let "Black Dog" share the herd's company with him. Such was not the decision of "John Kerr," a powerful bull of five summers, who immediately attacked the visitor savagely. As a result of his last encounter, "Black Dog's" spirits were high, but his wind was short, so "John Kerr" had little difficulty in thrashing him soundly in less time than it had taken the former to whip "Comanche." After this unwelcome reception, the panting "Black Dog" repaired to the farthest side of the pasture. Early in the afternoon when he had rested and regained his wind, the mighty wrath which had been kindled in his heart that morning goaded him on to another encounter with his victorious rival, "John Kerr."

When "Black Dog" topped the hill and started down the slope toward the herd, he gave a mighty snort and bawl which were answered by "John Kerr" in a way which seemed to bristle with defiance. This reply, however, did not frighten "Black Dog," who answered by viciously tossing his great shaggy head, then wallowing and violently thumping his hump on the ground and kicking his feet in the air. This formal announcement being over, he ambled leisurely toward the herd, emitting powerful "brawps," that sounded as if they were coming from the throat of a locomotive, while pawing the dust over his back as if he were master not only of the herd, but of the whole world. When "Black Dog" was about two hundred yards from the herd, he began threatening battle in dead earnest. Wallowing in the dust, the powerful brute would strike the turf mighty whacks with his hump, kick up his feet, roll his eyes, and toss his great, shaggy head. It was not long before "Black Dog" advanced to within about one hundred yards of the herd, then halted, and again pawed up the earth, while facing his adversary. After he had thumped his hump harder and tossed his heels higher than he ever had before, he arose and shook his head more fiercely than he had at any other time, and advanced in a trot toward his opponent. During all this time "John Kerr" had likewise been threatening battle, and now he trotted out of the herd to meet his adversary.

Then began as fierce a battle as ever took place on the plains between two members of the cow family. The two maddened brutes clashed with the force of a long line of freight cars bumping together, and each received the other on his horns. It was then very apparent that each tried to receive the other's blows on his horns and the top, or poll, of his head; also, that those curved, short, stout horns, instead of being placed too high up, as had seemed, and too far back on the bison's head to be of any use, are placed just right. When the horns are brought into play, the sensitive nose is far back out of harm's way. Vicious thrust was followed by skillful parry, and the blows fell fast and heavily. "Black Dog" beat down "John Kerr's" guard and gored him in the neck and shoulder. "John Kerr" stepped sideways, and right lively too, but "Black Dog" kept up with him, and for several seconds "John Kerr" was unable to get away from those merciless, twisting horns of ebony. The veteran fighter seemed to feel victory ahead, but his adversary, who was younger, longer winded, and more nimble, evaded the weapons of his opponent, and charging, beat past his guard and gave him a vicious side thrust in the neck that brought a handful of hair. This made the old monarch still more angry, and he charged savagely while "John Kerr" nimbly warded off the blows with his horns. "Black Dog" charged again and again, but each time his opponent received the blows on his horns. Finally "Black Dog" tried to push his adversary backward by means of sheer brute strength and weight, and made some progress—but at what fearful cost! Tearing up the turf as they went, the mighty brutes traveled southward about a quarter of a mile.

"Black Dog's" tongue was lolling; his feet were leaden weights. He had entirely given up the offensive and tried only to defend himself. "John Kerr's" horns tore off bunch after bunch of the kinky, chocolate-colored hair. Finally his horns found "Black Dog's" shoulder and he gored him mercilessly, but so thick is the old bull's hide that "John Kerr's" horns failed to bring the blood. Poor old "Black Dog," with lolling tongue and heaving sides, offered no further resistance. He was hopelessly whipped and "John Kerr" was master of the herd.

Even to this day "Black Dog" leads the life of a hermit, and "John Kerr" is absolute monarch over a realm of eight thousand acres and a herd of eighty-two buffaloes. But the monarch of the herd today will be the hermit of tomorrow. A younger and more powerful bull will succeed "John Kerr," just as he succeeded "Black Dog." The herd may have a new leader with the advent of this coming season, and "John Kerr" will have passed into oblivion.

*Reproduced from the *American Museum Journal*, issued by the Am. Museum of Natural History, New York.

[1]The fifteen bison that formed the nucleus of the herd in the "buffalo pasture" of the Wichita, were presented by the New York Zoological Society from its Zoological Park herd.—EDITOR.

Strength of Paper

FROM an examination of various papers, prepared with different proportions of rags, sizing and loading it appears, according to *Zt. angew. Chem.*, that the mechanical properties are improved by increasing the proportion of rags. Rosin sizing diminishes the strength, while animal sizing increases it. An increase in the proportion of rags, also sizing of any kind enables a larger proportion of loading material to be retained by the paper. Loading decreases the strength of all papers the percentage of loss approximating 2.2 times the percentage of loading material.

The Metric System*

Some Direct Applications to Practical Problems

By C. A. Briggs

Among insects, ants are found to have intelligence of a surprisingly high order. A study of their habits reads like a romance in the variety and complexity of their mode of life and methodical conduct of their affairs. Nevertheless it is a common observation that an ant bringing home food will, when it encounters a blade of grass, or a small straw or stalk standing in its path, generally climb all the way up one side and down the other instead of adopting the simple expedient of going around it. This conduct doubtlessly emphasizes the force of habit, but most of us will fail to see that the universality of this habit among ants contributes any special merit to their behavior.

In the same regard to human activities and to many common mental processes and methods employed in daily life we follow habit, and when obstacles are encountered, we often climb up one side and down the other instead of merely going around them. And to my mind and to the minds of all of you who are more anxious to improve and progress than to conceal our own weaknesses, imperfections fail to acquire any merit because of the fact that we are afflicted with them.

I have to present for your consideration some expedients whereby we can simply go around certain obstructions instead of climbing up one side and down the other.

The subject of my paper relates to the metric system—a system of weights and measures which gives us a means of avoiding the peculiarly luxuriant growth of grass and straw stalks that represent our English system of weights and measures.

Metric Units of Length.—The meter is the fundamental standard of length of the metric system, and I hold in my hand a stick just one meter long. This is divided into tenths called decimeters, the decimeters are divided into tenths called centimeters, and the centimeters are subdivided into tenths called millimeters. A further subdivision of the millimeter, into one thousand parts called microns, for scientific purposes, is often made. There are one million microns in a meter, a thousand millimeters in one meter, and there are one hundred centimeters in one meter. A centimeter is just one percent of the length of a meter.

The multiples of the meter are as follows: 10 meters are equal to a dekameter, 10 dekameters are equal to a hectometer, and 10 hectometers or one thousand meters, are equal to a kilometer. Frequent reference is made to kilometers in news items regarding events of the European war.

As a rule lengths are given in millimeters, centimeters, and kilometers, decimeters being used sometimes, but as far as my personal experience goes, reference is not often made to dekameters or hectometers.

It is important to note that you can convert from any one of the units chosen to any other by simply making the appropriate change in the decimal point. You can change from kilometers to microns by moving the decimal point over nine places. There are just one billion microns in a kilometer.

Metric Units of Capacity.—The unit of capacity of the metric system is the liter. A liter is equal to a cubic decimeter. This has the following suvdivisions and multiples:

10 milliliters = 1 centiliter
10 centiliters = 1 deciliter
10 deciliters = 1 *liter*
10 liters = 1 dekaliter
10 dekaliters = 1 hectoliter

The liter is represented by this flask which has a capacity of one liter to the mark on the neck, the brass measure which is a standard liter measure, and this cube which is a cubic deciliter. A cubic meter contains one thousand liters. This cubic meter is the unit of volume used in excavations similar to the use of the cubic yard in the English system.

There is a very slight difference between the cubic decimeter and the liter, but this will be considered in the following section on the units of weight of the metric system.

This little cube which I hold is a cubic centimeter and has a volume of one milliliter. This cubic centimeter is the unit of volume used in chemistry.

The relationship existing between these various units of volume will help us to get some interesting concepts. It is often said that when we come to a figure like a million it is impossible for the human mind to form an adequate idea of such a large number. You will be interested, therefore, to note that this little cubic centimeter is just one-millionth part of the cubic meter.

We can now carry this comparison further. I have distributed among you some paper strips on which appears a metric scale subdivided into millimeters. Imagine now a cubic millimeter—it is not difficult. There are just *one billion* of these little cubic millimeters in one cubic meter.

In order to convert from one unit to another all that is necessary is to change the position of the decimal point. I believe that most of you will see that the relation between the units not only is one of maximum simplicity, but one which has enabled many of you to get in very direct manner a conception you never had before.

Metric Units of Weight or Mass.—The metric weights are connected with the units of length and capacity in the simplest and most useful manner possible. The fundamental unit of mass or weight in the metric system is the kilogram.

Practical Applications of the Metric System.—The liter, the unit of capacity of the metric system mentioned in the preceding section, is the volume of a kilogram of water in the temperature of maximum density, 4° Centigrade; this volume is not exactly equal to a cubic decimeter. This difference, however, is only of interest in scientific work of high precision. The side of a cube required to contain a kilogram of water at the temperature of maximum density is just about one micron or one one-thousandth of a millimeter larger than a decimeter.

This small difference is, of course, due to the inferior scientific equipment and methods of the time in which the standards of the metric system were constructed. As a matter of fact, there would be little, if any practical advantage in having the volume of a liter exactly equal to a cubic decimeter, as when such small differences become important it is also necessary to make proper allowances for a multitude of conditions such as temperature, moisture in the air, barometric pressure, and things of that character.

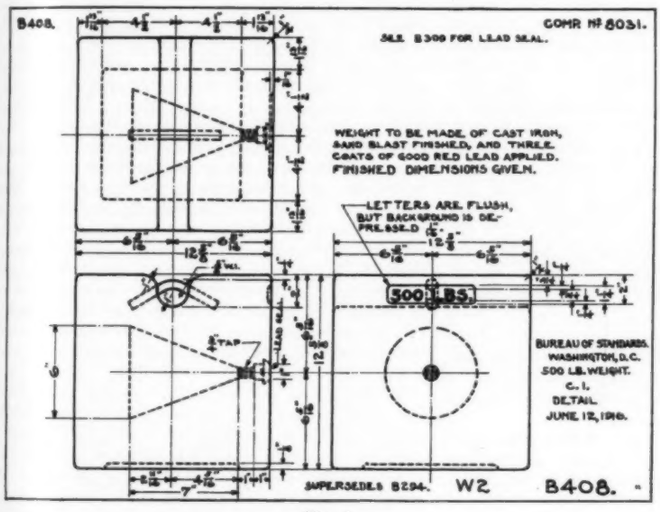

B408.
COMR No 8031.
SEE B309 FOR LEAD SEAL.
WEIGHT TO BE MADE OF CAST IRON, SAND BLAST FINISHED, AND THREE COATS OF GOOD RED LEAD APPLIED. FINISHED DIMENSIONS GIVEN.
LETTERS ARE FLUSH, BUT BACKGROUND IS DEPRESSED
500 LBS.
BUREAU OF STANDARDS. WASHINGTON, D.C. 500 LB. WEIGHT. C. I. DETAIL. JUNE 12, 1916.
SUPERSEDES B294.
W2
B408.

Fig. 1

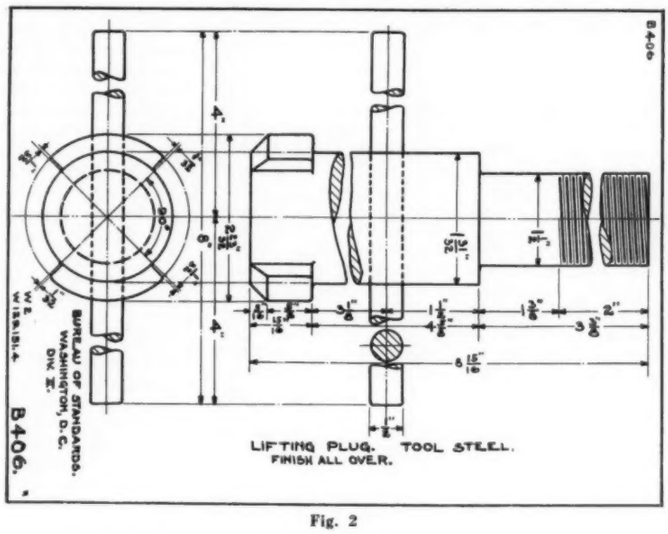


Fig. 2

The following table gives the relation between the metric weights:

10 milligrams = 1 centigram
10 centigrams = 1 decigram
10 decigrams = 1 *gram*
10 grams = 1 dekagram
10 dekagrams = 1 hectogram
10 hectograms = 1 *kilogram* (1000 grams)
1000 kilograms = 1 metric ton

A cubic meter of water will weigh a metric ton. A cubic decimeter of water will weigh one kilogram, and a cubic centimeter of water will weigh one gram.

It is most convenient and scientific to express the density of materials in the terms of the density of water as is usually referred to by specific gravity. It follows that in the metric system the weight of an object is equal to its volume times its specific gravity. For instance, in this little centimeter cube the weight in grams is just equal to its specific gravity. This little decimeter rule is ten centimeters long, one centimeter wide, and one-tenth centimeter or one millimeter thick; its volume is, therefore, also one cubic centimeter and its weight in grams is equal to its density.

Perhaps I have succeeded in making a very simple matter appear very complicated, but these relations between the metric quantities have been pointed out in order that I might indicate to you the wonderful flexibility and beauty of this system.

Let us now consider some of the direct applications of the metric system to the ordinary problems that we encounter in our work.

A sliding poise on a wagon scale beam was out of adjustment and it was desired to adjust it to the correct weight in one operation. The capacity of the sliding poise was 1000 pounds, the corresponding loose weight on the counterpoise pan on the end of the beam

*A paper read before the National Scale Men's Association at Chicago, March, 1917.

was one pound. The correct weight for the sliding poise can be obtained by measuring the distance between the fulcrum knife edge and the knife edge at the end of the beam, and the length of the movement of the sliding poise which corresponds to 1000 pounds.

This distance from knife edge to knife edge is 889.2 millimeters, the stroke of the poise is 677.9 millimeters, the weight of the poise required is

$$\frac{889.2}{677.9} \times 1 = 1.312 \text{ lb.}$$

If we have a decimal set of pound weights or a set of metric weights, the counterpoise weight can be adjusted without difficulty. This method will be practical for every day use.

This, however, is not true if we use our English system of weights and measures. Let us try for example.

In the English units the distance between the knife edges as measured was found to be 2′ 2 11/16″ + 1/10 × 1/16″ and for the movement of the sliding poise the measurement was 2′ 2 11/16″. Now after reducing this all to decimal inches, you are in a position to make a division similar to that performed just previously and determine that the weight of the sliding poise should be 1.312 lb., if you did not make a mistake somewhere.

The next step is to get the equivalent of this demical value of the counterpoise in pounds, ounces, their binary subdivisions and grains. How many of you here could work this out in five minutes? How many of you here could work this out in five hours?

I remember the first time that I was out on an inspection trip. I had never been under a wagon scale before and everything was new to me. However, I was accustomed to the metric system and had in my pocket a metric tape divided into millimeters. This identical problem came up. The movement of the poise and the distance between the knife edges on the metric tape were measured and the weight to which the poise should be adjusted was easily and quickly determined. However, neither metric nor decimal pound weights were available. It was therefore necessary to convert the decimal value of the weight into equivalent pounds, ounces, their fractions and grains. For some strange reason this was done without error and the poise when adjusted and placed on the scale was found to be correctly adjusted. But I would certainly dislike very much to risk making the conversion again under similar circumstances.

Here is one of the many cases where a method which is practical and efficient becomes ridiculous when the English units are employed.

Just a few days ago, I was looking through my notes taken on this first trip of mine and found a memorandum of a test of some loose counterpoise weights whose nominal value was two pounds. These were tested by the method of substitution with the following results:

No. of Weight	Lb.	Oz.			Grains
1.... =	1 +	15 +	½ +	⅛ +	1
2.... =	1 +	15 +	½ +	⅛ +	12
3.... =	1 +	15 +	½ +	⅛ +	12
4.... =	1 +	15 +	½ +	⅛ +	0

How can any one of you here tell me off hand the error in these weights?

Figure 1 is taken from drawing B408 of the Bureau of Standards giving the design of a 500-pound cubical cast iron weight. There was a previous design and drawing of this weight but on account of an error in adding some of the awkward fractions of inches it became necessary to redesign this weight and make a new drawing.

Time was lost in the following particulars which would not have been the case if the metric system had been used:

1. It was necessary to redesign the weight.

2. Certain of the dimensions of the old design were converted from common fractions into decimal fractions.

3. It was necessary to convert the weight of cast iron and lead from pounds per cubic foot to pounds per cubic inch by dividing by 1728.

4. Time was lost in finding that the weight of cast iron and lead were not given in pounds per cubic inch in either of the two handbooks available.

5. After the dimensions were obtained for the final design it was necessary to convert them from the decimal fractions into the common fractions for placing them on the drawings.

6. The drawing of the correct design had to be made.

Considering the question of the redesign only, somewhere between 50 and 80 per cent. of the time would have been saved if the metric system had been used.

Figure 2 was taken from drawing B406, giving the design of the lifting plug used for handling the large weights of the test car of the Bureau of Standards. Note the odd fractions that have to be added in checking the drawing:

What is 5/16+5/8; what is 5/16+3 1/8; what is 15/16+4 5/8+3 3/8?

According to a statement made at the last Conference on Weights and Measures held in Washington last year, by a manufacturer of a dry-goods measuring and computing machine, dry-goods are usually sold in yards, and the fractions one-half, one-quarter, and one-eighth yards, and his device was marked accordingly; and he further emphasized that data taken by him showed that on the average the clerks made a mistake in 1 out of 11 sales slips. This is of interest to the people who pretend to see some special virtue in the binary subdivisions that occur in some English weights and measures.

The use of cast iron in the levers of scales makes it important to know as much as possible about the properties of cast iron under transverse bending stresses particularly since cast iron does not behave like most other materials. However up to the present time there has been very little data on this subject. In my files I have clippings from two papers giving results of tests made on cast iron under transverse bending tests, and the results are quite interesting and will be of additional interest and importance when other tests have been made. Both of these papers are from England.

In one, which appeared in "Engineering", of London, for Oct. 9th, the results are given in hundredweight per square inch. How many of you know what a hundredweight is? Some of you may know that this charming and characteristicly English unit of weight is not 100 lb. but 112 lb.

I asked an Englishman why such an awkward unit was chosen and was paralyzed by his reply that "it was because a stone weighed 14 lb." This indigestible statement I pass on to you.

The other paper appeared in a different issue of the same magazine and the results were reported in tons per square inch. This was a long ton of 2240 lb.

These, to my mind, are expert methods of concealing information.

If the metric system had been used, I would have been able to change the original data to any unit convenient for my purposes or methods of thought by simply changing the decimal point.

A few years ago I acted as cashier for a waterworks company which at that time had about 5000 accounts. Those using meters paid so much per thousand gallons.

The meters read in cubic feet.

You have no idea of the convenience of this arrangement. The meter readings were sent with the bills but the bother of converting the reading to gallons was sufficient to prevent all but industrial concerns from checking their bills. There was no dishonesty involved but there could have been. It was very convenient not to be bothered with customers finding mistakes. With the metric system, all conversions would have required only a change in the decimal point and the comforting barrier to checking bills would have been absent, but things would have been more businesslike.

Now let us take up a subject that is as close to our hearts as to our pocketbooks,—our stomachs. The stomach appears to have first place in domestic economy. The preparation of foods is a subject which transcends all others in the study of household affairs.

Now open a cookbook and observe the wide variety of unrelated measurements that are used. Look through the formidable array of weighing and measuring utensils recommended for culinary matters of the household in Circular No. 55 prepared by the Bureau of Standards and see the variety of awkwardly related and unnecessarily variegated units which are required at the present time, all of which in the metric system could be replaced by a small series of simply related units.

Is there any wonder that after the great effort that is expended by schools of domestic economy, to induce women to cook systematically and scientifically, that they abandon their measures in favor of hope and instinct, when they are not provided with rational and scientific weights and measures?

The metric units are particularly adapted for household use—a liter of water weighs one kilogram, a cubic centimeter of water weighs one gram. With the metric system things can be weighed or measured with equal freedom, and materials which do not have the density of water are easily converted from weight to measure with only a mental approximation being necessary.

When it comes to the smaller units required for salt, baking powder, flavoring, etc., the cubic centimeter and decimal subdivisions will be found peculiarly well adapted, or a scale weighing in grams will serve.

Being part of the same decimal system, the relations between these small quantities and the larger ingredients can be perceived, and a fact which comes to but few women, and then after long years, that a fixed relation generally exists in a certain class of cooking between the amount of salt, flavoring, etc., and the large ingredients, will become known to everyone naturally—if the metric units are used.

By having receipts in metric units, it becomes a simple matter to convert it to provide any change in the specified quantity by multiplying the constituents by the proper factor, and the metric measures will provide the necessary facilities for carrying out the work in an efficient manner.

In the conduct of the European war now going on the metric system is admitted by England to give Germany a very important advantage in getting the highest industrial efficiency.

Observation Balloons and Artillery Fire

MANY reports have come to us describing the devastating showers of high explosive shells that are thrown upon the enemy's lines of defense for hours at a time by the Allies in preparation for an advance of troops, and which plow up every yard of the ground, obliterating every shelter that could harbor a soldier or a machine gun, and the accuracy of the fire by the gunners is attributed to aircraft generally. Usually it is assumed that it is the aeroplanes which furnish the information that enables the artillerymen to aim their guns so accurately, and undoubtedly they do supply much valuable information; but as they must be continually on the move, and are often at great distances from the batteries, especially when flying behind the enemy's lines, their reports cannot be as continuous as is necessary to enable every shell fired to accomplish the desired purpose, and it is on the captive balloons that the gunners must rely for instructions and prompt information.

These balloons are, as a rule, located just behind the batteries, and are anchored in place by a cable long enough to enable them to rise sufficiently high to give the observer a clear view over the range of the guns, which themselves are generally placed behind some protecting ridge where they cannot see the enemy or be seen by them. Perched in the basket that swings beneath the balloon is the observer, who has on a board in front of him a large detail map of the region below, and this map is divided by lines into small squares, each one of which is numbered. In the battery below the officer in charge has a similarly divided map, and a telephone line from the observer to the artillery commander provides a quick means of communication between them. It is then a simple matter for the observer to locate the position of the enemy on his map, and to call the number of the square to those below, together with any other necessary information. The artilleryman is thus enabled to point his guns in the proper direction, and to estimate the distance, and consequently the elevation to which his guns must be adjusted. Then he fires a round and awaits results. The observer above watches carefully with his glass for the explosion of the shell, and quickly communicates to those below any corrections in aim to enable them to plant their shots accurately and effectively, and the fire can then be continued until the trench or machine gun emplacement is shattered.

The illustration on the first page of this issue shows a balloon observer at work in his lofty perch, and is from an official English photograph taken on the battle front in France.

As these captive balloons have no means of protecting themselves, they are always liable to the attacks of the enemy aeroplanes, and consequently whenever they are up there is a squadron of fighting aircraft circling around to ward off hostile machines. There are also other squadrons of powerful aeroplanes scouting at the same time over the lines of the enemy endeavoring to send down their balloons, so that it will not be possible for opposing batteries to work effectively; and this is one of the most important points in the "mastery of the air," of which we hear so much. that is to protect the efficiency of the artillery fire of the Allies, while blinding that of the enemy.

Osmotic Pressure*

THE three papers that were brought before the Faraday Society recently as contributions to a General Discussion on Osmotic Pressure, approached the problems from three different standpoints. Prof. A. W. Porter, F.R.S., of University College, London, finds the explanation of the phenomena in the kinetic theory and accentuates the influence of the solute, the dissolved substance; Mr. W. R. Bousfield, K.C., F.R.S., attributes the main function to the solvent, which in most of the cases considered is water; Dr. Frank Tinker, of Birmingham, sees the most important factor in the semi-permeable membrane which separates solution and solvent. No doubt all these factors are concerned, and all scientists would welcome a real explanation of the phenomena, which are biologically of the highest importance and of great interest mechanically and physically, inasmuch as an understanding of these problems would help to bridge the gulf between living and dead matter. The discussion confined itself to the physical side and theory. Commenting on the three standpoints indicated, Sir Oliver J. Lodge, who presided, pointed out that the water, not the solute, was the thing which evaporated from a hot aqueous solution and which froze in the cold, which penetrated the membrane, and which yet was kept within the skin of delicate fruits exposed to the tropical sun. Vapor pressure, depression of freezing-point and osmotic pressure were all closely related.

By osmotic pressure Prof. Porter, who opened the discussion, understands the equilibrium difference of pressure between a solution (say, of sugar) and the pure solvent (water) when separated by a membrane which is permeable only to the solvent, the pressure being greater in the solution than in the solvent. Since the Faraday Society discussed the problem in 1907, he said, progress had been made in theory and experiment. The study of the Brownian movements had shown that there was a kinetic theory of liquids as there was of gases, and the kinetic theory of osmotic pressure had been put on a safer footing. All gases deviated from the laws for perfect gases, but nobody condemned the kinetic theory for that reason; the small particles suspended in a liquid behaved like gas particles, the dissolved particles should behave similarly, and it was not fatal to the kinetic theory of osmotic pressure that it strictly applied only to diluted solutions. The problem of the membrane was important, but subsidiary. Provided the membrane were really semi-permeable—and such membranes had been made—the osmotic pressure really depended upon solute and solvent, but not on the nature of the membrane, the canals of which should, of course, be small compared with the range of molecular forces. There was only one theory on which the osmotic pressure could be calculated, and that was the kinetic gas theory. There were complications, no doubt; but the true characteristic equation was not yet known for a single liquid, and the problems of binary mixtures were much harder.

Passing to the complications and to the interpretation of the experiments mainly carried on by H. N. Morse and Frazer and their collaborators in Baltimore (sugar solutions of all concentrations between 0 and 80 deg. C.) and by Berkeley and Hartley over here, Professor Porter said that he found that the formula of Hirn (1865): $P(v-b) = R\,T$, applied best where b did not differ much from the volume of sugar present. It did differ, however, and that was apparently due to the hydration of the sugar, the association of one sugar molecule with several water molecules, 5.3 on an average. Such associations between substance and solvent are, of course, assumed for many reasons; Prof. Porter considered that the layer of water round the sugar molecule was in kinetic equilibrium, continually breaking up and forming again; the hydration number hence had a statistical value. The experiments indicated that the hydration number was very high at low temperatures and low concentration, being 53 for Morse's decinormal solutions at 0 deg. C., but decreased as temperature and concentration rose, to 3 and possibly less. At high hydration the radii of the sugar sphere and the 20 or 30 water spheres around it in a single layer would yet be only as 6:2.6. Prof. Porter finally stated that the recent researches of Mr. Orson Wood and himself showed that the osmotic pressure could also be calculated from the latent heat of dilution.

Dr. Tinker, speaking next, remarked that recent thermodynamical speculations suggested that the osmotic pressure was a complex function of vapor pressure, compressibility, specific volume and other diverse factors—the objection to be raised is, of course, that thermodynamics cannot explain the *modus operandi*—while the kinetic side of the subject had almost remained stationary. The common membrane of copper-ferrocyanide type was built up of colloidal particles varying from 50 to 400 $\mu\mu$ in diameter; the pores were from 10 to 20 $\mu\mu$. Crystalloidal molecules would be able to pass through those pores, but they would be under the influence of surface phenomena. Those membranes seemed to exert a selective adsorption; the copper-ferrocyanide film, *e.g.*, adsorbed water rather than sugar from the aqueous solution and more water from pure water than from sugar solution, and was hence permeable to water, which flowed inward to the sugar solution. The vapor pressure above a pure solvent was, as a rule, greater than the pressure above the solution, and osmotic flow and vapor distillation were essentially similar, both being diffusion phenomena, though not identical. The water concentration in the membrane pores was very high, 20,000 times as great as the concentration of water vapor proper. In some respects the membrane might be likened to a vacuum. Other membranes had quite different selective actions; thus the inner skin of the barley seed was permeable to phenols, fatty acids and amines which gave low surface tensions, but not to sugar and many inorganic salts which gave high surface tensions (Adrian Brown and Tinker). The direction of osmotic flow was from the solution which generated the greater vapor pressure; and Dr. Tinker would define osmotic pressure as that hydrostatic pressure which, when applied to the solution, raised the vapor pressure of the latter up to that of the pure solvent. Abnormalties in vapor pressure explained most of the abnormalties in osmotic pressure. Dr. Tinker further dwelt on some new experiments and deductions of his note contained in his printed paper. We will at once mention here a critical remark to which the Earl of Berkeley, F.R.S., subsequently limited himself owing to the lateness of the hour. When solid potassium dichromate at the bottom of a cylinder and concentrated sulphuric acid above it were brought in contact, the red chromic acid liberated diffused into the sulphuric acid, although neither substance had any vapor pressure. With respect to his own method, Lord Berkeley stated that it admitted an accuracy of 1 in 800; Dr. Porter hoped to attain that accuracy by his latent heat method. As regards the views of Prof. Porter and Dr. Tinker, we would further refer our readers to our report on the British Association meeting at Newcastle.[1]

Mr. Bousfield would not attempt to give a *résumé* of his rather long paper, as no time would be left for the discussion, and he put questions. What he has been suggesting with Dr. T. M. Lowry since 1905 is a ternery mixture containing hydrol or steam molecules H_2O, dihydrol $(H_2O)_2$, and trihydrol or ice molecules $(H_2O)_3$, the dihydrol being the main constituent, trihydrol predominating at low, and hydrol at high temperatures. When sugar or some other substance was introduced into water, he stated in his paper, the dihydrol proportion increased; hence vapor pressure and freezing-point were both lowered. When a solution was in osmotic equilibrium with the pure solvent through a semi-permeable membrane, the vapor pressures of the solution and the solvent were the same. To produce this equilibrium the solution must be under sufficient liquid pressure to raise its vapor pressure to the required equality. The general relation between liquid pressure and vapor pressure was $V\,d\,P = v\,d\,p$, where the capitals concerned the liquid and the small letters the vapor. V was not the specific volume of the pure water, however, but that of the water as it existed in the solution. The solute combined with some of the water, and in so doing eliminated some of the trihydrol and hydrol, and thus changed the water itself. The further deductions led Mr. Bousfield to the equations: $P/R'T = \delta p/p = \Delta/F' = i/(h-n)$, where $R' = 1000\ R/e$, $F' = 1000\ F/e$, R and F being the gas constant and freezing-point constant, e the molecular weight of steam (18.016), P the osmotic pressure, p the vapor pressure of water, $\delta\,p$ the lowering of the water pressure by the solute, Δ the freezing-point depression, $i = 1 + a$ (where a was the ionization), h the number of water molecules (counted as H_2O), n the number of combined water molecules per molecule of solute, and $h-n$ the number of pure water molecules per molecule of solute. The osmotic pressure depended upon the activity of the steam molecules. These relations, Mr. Bousfield said, held for electrolytes—he gave tables for lithium chlorides—as well as for non-electrolytes, and for dilute and concentrated solutions.

Dr. S. A. Shorter remarked that Mr. Bousfield's equations were simply verifications of thermo-dynamic laws, and it did not matter what shape Mr. Bousfield gave to the last ratio containing the n; Sir Oliver Lodge and Mr. Dampier Whetham, F.R.S., of Cambridge, also had doubts about the independent determination of the n. But Dr. Shorter went further; he did not agree with any of the speakers, having his own theory about surface layers, vapour pressure, miscibility of liquids, etc., in which molecular forces played a prominent part. Professor J. C. Philip, of the Imperial College of Science, said that Dr. Tinker had dwelt on the sizes of the pores in the membranes, but did not depend upon those pores after all; for the pores were big enough to allow large colloidal particles to pass, yet the pores were supposed to stop sugar. The work of Bechhold showed, however, that the size of the pores came in sometimes. As regards hydration, Dr. Philip had in recent experiments on the partition coefficient of ethyl acetate, phenol, etc., between benzene and aqueous sugar solutions found hydration numbers of 11 for dilute and 6.5 for concentrated solution; these values were higher than his former values, and he had observed considerably higher hydrations in other cases. Dr. G. Senter agreed on the whole with Dr. Porter, though the very large decrease in the hydration attributed in one of Porter's tables to small differences on the concentration looked improbable. Mr. Whetham also agreed with Dr. Porter, as the kinetic theory was the only one which allowed of calculations, though he himself would like to substitute some chemical theory for it.

In closing the discussion after Professor Porter had briefly replied, Sir Oliver Lodge, referring to one of Mr. Bousfield's remarks, drew attention to the enormous internal pressures or cohesive forces within a liquid. When he tried to put the problem tersely the discussion threatened to become lively again, although the clock hand was approaching 11. Sir Oliver suggested: Take a trough full of water, put a semi-permeable partition halfway across it; that membrane will not harm the water; now add sugar to the one compartment. The sugar goes in like a gas into a vacuum, and the osmotic pressure is the increase of pressure due to the sugar, the water pressures on both sides of the membrane remaining the same. Was that broadly acceptable? The objections are, of course, that the sugar takes up part of the volume, and that there is dissolution, accompanied by contraction or dilatation, heat changes, and other changes. The suggestion well illustrated the complexity of the problem.

*Engineering.

[1] See *Engineering*, October 13, 1916, p. 347.

Proposed Utilization of Coal Workings for a Tunnel Under the Firth of Forth

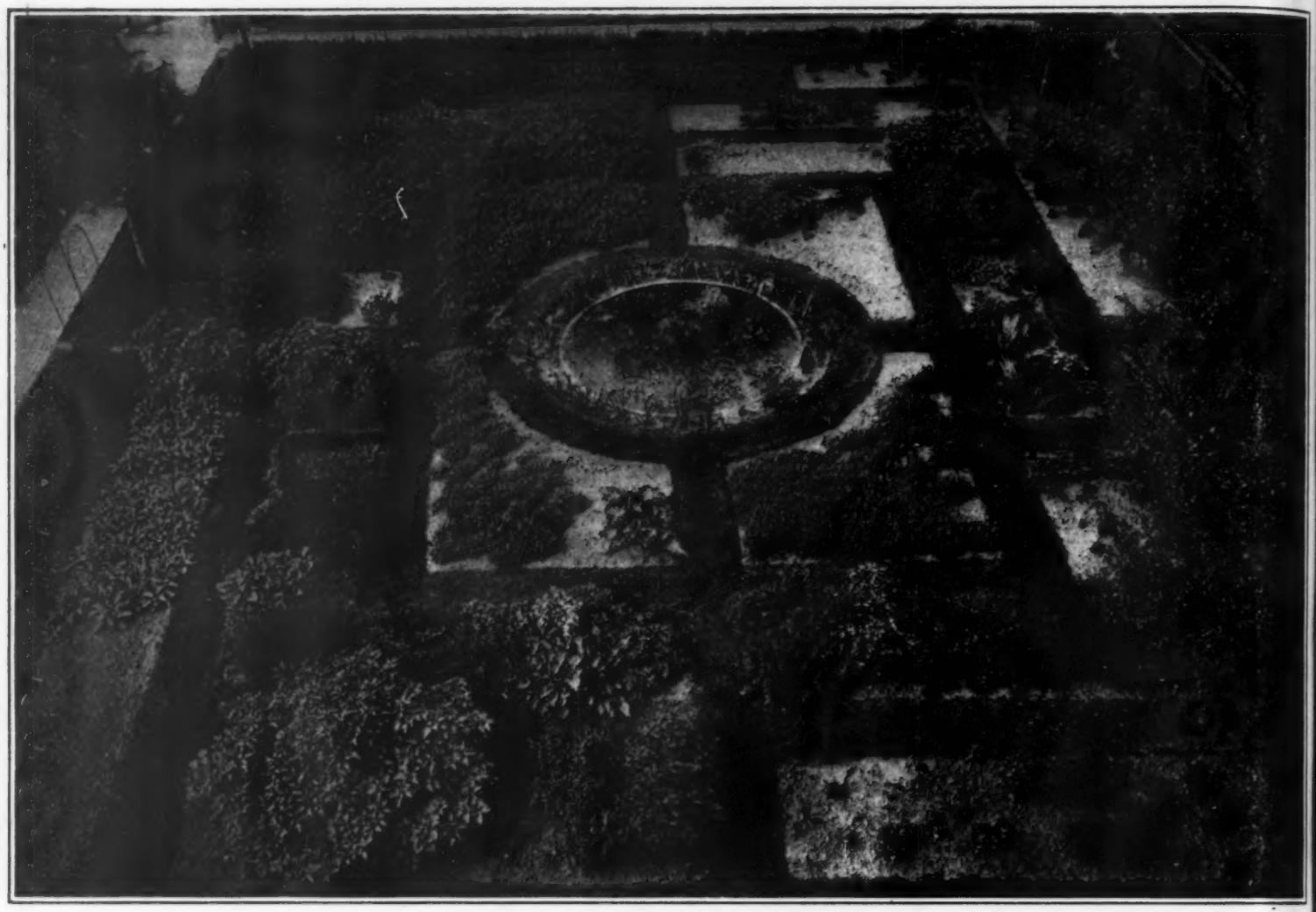
IT was suggested at a recent meeting of the Mining Institute of Scotland that a tunnel should be constructed under the Firth of Forth, connecting Fifeshire with Edinburgh. It was not proposed that such a scheme should be undertaken solely as a commercial venture, or even for the purposes of naval and military strategy. A tunnel would cater for goods and passenger traffic, and would also be useful by providing an alternative crossing in the event of the Forth Bridge being damaged.

The principal argument in favor of constructing a tunnel is, however, that the work could be largely done in the form of coal mining, the coal being excavated and marketed, and the borings directed from the respective sides so as to meet ultimately and constitute a passage for traffic. For a number of years the miners on both sides of the Forth have been working the same seams of coal. On the north side the seams are worked from the Low Valley Field Colliery, about five miles west of Dunfermline, and on the south side from the Lowthians pits. In each case the excavations are going under the firth, and as at this point the estuary is only two miles in width it would be only a question of time—if the work were directed properly—when the two sets of men would meet about half way across. Already, an inspector of mines states there are excavations two miles in length, projecting under the firth, though these could not be utilized as part of a tunnel.

There would be difficulties of haulage and ventilation, but it is believed that these could be overcome. A boring could be made at first capable of taking an ordinary seven-ton railway wagon. At the side of this boring there could be erected a single screening unit, so that the coal excavated could be screened and put into wagons for direct conveyance to the markets. So far as operations under the Forth have been carried out the conditions as to gas and dust have been found to be such that a tunneling scheme could be undertaken with perfect safety. The work could be carried out economically, because the coal obtained would always more than pay for the cost of labor, materials, and supervision.

Metal Spraying

IN a paper on the process of metal spraying before the American Institute of Mechanical Engineers, the speaker pointed out that the process could not be used for coating materials that were afterwards to be bent at a sharp angle, or used in a state of tension. It was also stated that the air pressure necessary for working the process had, by improvements in the apparatus, been reduced so considerably that satisfactory work can now be secured with but eighteen pounds.



An experimental drug plant garden at the University of Nebraska

Reducing Drug Plant Cultivation to a Science

By R. P. Crawford

Drug plant cultivation is an unexplored field and, while at first sight simple enough, probably involves in reality more intricate problems than any other branch of agriculture. Firms and individuals that may have developed this highly specialized art for their own use certainly cannot be expected to turn over the results of their experience for the public benefit. Heretofore, owing partly to the fact that a good proportion of our drugs were being imported prior to the war, comparatively few public institutions have given more than passing notice to this branch of agriculture. The University of Nebraska through its College of Pharmacy is one of the few institutions that is taking up the curing, preserving and distilling of drugs besides the actual raising of drug plants. Special attention is being given to the successful handling of medicinal plants in the Middle West and a practical course is now being offered in the raising, curing and preserving of crude drugs.

Approximately 110 different varieties of drug-producing plants are raised in the experimental garden, which is laid out in symmetrical form as an integral part of the campus design, occupying about an acre. The garden includes all types of drug plants, from the tropical which have to be kept in the greenhouse most of the year to the plants which grow wild in the surrounding country.

Many interesting problems naturally are being attacked in the work. In the past desultory gathering of herbs was often calculated to supply the country's quota of certain drugs. In other cases attempts have been made to raise drug plants with fair results. But this procedure, it is pointed out by Dean R. A. Lyman of the Nebraska College of Pharmacy, can never offer permanent outlook for either the drug companies, which purchase the supplies, or for the person who raises or gathers the crude article, unless the work is standardized. In reality the limits to scientific cultivation can hardly be conceived. For instance, there is the question of selective breeding, the development of certain plants which have more potent drug qualities than others. In fact one might mistake a really good drug-producing plant for a poor specimen. In the case of digitalis, for example, which it had been predicted could not be raised successfully in Nebraska, the plants did not attain the luxuriance of those grown in other climates, but the leaves were found to have better drug qualities than those from plants raised elsewhere. Some thirteen different varieties of this plant were grown at one time in the garden, and while only one of them so far has been known as a producer of medicinal glucosides, it is believed that experiments may prove that some of the unknown varieties are just as important.

The person who essays to raise drugs for market is interested in just one fact, the amount of drug that he can get out of a plant. This governing factor may lie in the way the plant is cultivated, the time of harvesting as well as the part of the plant utilized for securing the drug, or it may lie in some cases in the manner in which the drugs are cured or distilled. Consequently it will be seen that drug plant cultivation is far from easy and the institution that works out these problems in connection with several score different plants has a difficult task ahead, but one which may pave the way toward American independence in drug science.

At the present time the Nebraska College of Pharmacy secures its supply of crude drugs largely from its own garden. Many plants, it has been found, can be raised with a good degree of success in the Middle West, even without the aid of a greenhouse for the early spring months. Among them are the mints, both peppermint and spearmint, henbane, from which hyoscine is derived, digitalis or foxglove, purgative rhubarb, camomile, lavender, the mustards, sage, hydrastis or golden seal, and Indian hemp. Many drug-producing plants, it is needless to point out, are very poisonous and care should be taken in handling them as well as in preventing domestic animals from feeding on their leaves.

Electrical Furnace Being Rapidly Adopted

Early in 1910 seven electric furnaces were at work in Great Britain. Eighteen months later the number had increased to 16, which figure remained stationery for another year and a half. At the beginning of 1916, 46 furnaces were in operation, and during the year an additional 42 furnaces were set to work, making a grand total of 88 in operation or under construction at the beginning of 1917. This amounts to about 19 per cent of the world's total. The corresponding figures for the United States are: At the beginning of 1910, 10; in July, 1913, 19; in January, 1915, 41; January, 1916, 73; and at the beginning of 1917, 136. During the last three years Germany has increased her furnaces from 34 to 82, and Austria from 10 to 18. According to a booklet issued by the Society for Electrical Development, of the furnaces installed, the Héroult type leads, the number installed being 181 out of a total of 471. The Rennerfelt comes next, with a total of 70. The induction type takes the third place with 50, and the fourth place is taken by the Grönwall-Dixon (Electro-Metals) type, with 29. Among the remainder, there are 24 Stassano, 23 Girod and 20 Greaves-Etchells furnaces.

—*The Engineer.*

Luster of Stones

There are two methods in use for improving and enhancing the hue of certain stones in some degree, namely, one by placing foils suitable for the purpose under the stones in close settings, and the other by painting the backs of the stones with some pigment or stain of the same hue as the stone, or of some other which is intended to modify and change the hue of the stones to the desired color. Foils are thin plates of copper or tin, copper being mostly used. The coloring of foils may easily be effected. They are prepared as follows: Take copper plates rolled very thin and of a size of from four to six inches square, polish them with rotten stone till they shine to give them as much brightness as possible, and they will then be ready to receive the desired color. The pigments used for painting the foils may be mixed with either oil, size, or varnish, or with water rendered sticky by gum arabic. When a deeper color is wanted in the sapphire, Prussian blue is used mixed in oil, and it should be spread more or less thinly on the foil according to the deepness or to the lightness of the color required. In common cases, however, of coloring foils for the backs of stones, any of the colored pigments may be, without much trouble, mixed with isinglass size in the same way as the potter prepares his vitreous substance for use in miniature painting.

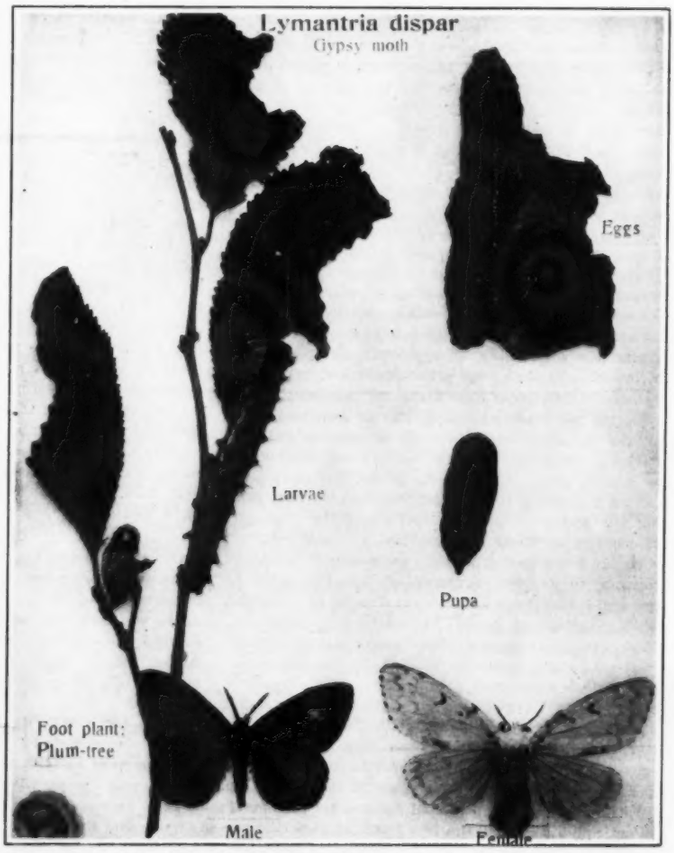
—*The Jeweler and Metalworker.*

Some Common Insect Pests

A cabbage butterfly depositing her egg. This insect causes great damage to the cabbage crop all over the country. Her offspring, a small green caterpillar feeds exclusively upon cabbage destroying the leaves and thus preventing them from heading

A spider lays its eggs in clusters like bunches of tiny grapes adhering to one another by the nature of their sticky coating. They number nearly 200 and are encased in a tough silken covering when the full number have been laid

Fortunately the ravages of the cabbage butterfly are held in check by a tiny parasite an ichneumon fly which stings the caterpillars and lays its eggs in the growing tissues. The eggs hatch within the body of their living host feeding there until full grown, when they burrow out to spin their cocoons as shown above. This causes the death of the caterpillar, and saves the cabbage from being ruined altogether



Life history of the Gypsy Moth. This well-known pest causes irreparable damage to our apple and shade trees. The illustrations show in detail, the different stages of the species and a brief study of them will serve to make one familiar with the pests. They should be destroyed wherever found. Even the destruction of one moth may save a great area from devastation

Concrete Structures in War*

Their Resistance to Shell

LONG before the outbreak of the present war ordinary concrete was widely employed for military structures of many kinds, and particularly in the construction of permanent fortifications. Before the almost irresistable effects of modern high-explosive shells were clearly realized much more faith was reposed in the resistance of plain concrete than is entertained today. The comparative ease with which the powerful forts of Liège, Namur, and Antwerp were destroyed by high-explosive shells fired from heavy siege guns came as an unpleasant surprise to the Belgians as well as to the Allies. There is something to be said on the other side, however, for it is reported that investigations have since proved that the concrete in some of the Belgian forts was of distinctly poor quality, and in the case of one fort at Namur, it is said that the material was so inferior that the concrete supporting a steel turret was demolished by a single shell.

An interesting illustration of the utility of concrete in warfare is afforded by the conversion of the island of Heligoland into a powerful fortress and naval base. When this place was handed over to Germany it was chiefly used as a bathing resort, and was rapidly crumbling away under the influence of waves and currents. As soon as it came into their possession, the Germans began to build groynes, breakwaters, and sea walls, in order to arrest erosion, and thousands of tons of cement grout and concrete were filled into crevices in the cliffs, until, to use the words of one who visited Heligoland in 1912, "the island was literally stuck together with cement and ferro-concrete." Further applications of concrete are to be found in fortifications with underground chambers and galleries, and an artificial harbor, capable of affording safe anchorage for an entire fleet. Thus, concrete has enabled the Germans to create from a moribund islet what they believe to be an impregnable fortress.

PORT ARTHUR FORTIFICATIONS

So far as reinforced concrete is concerned, the first authenticated instance of its use in actual wafare was probably furnished by the fortifications constructed of Hennebique ferro-concrete at Port Arthur. The efficiency of the combination was demonstrated during the Russo-Japanese war, and the successful results there obtained may have suggested the employment of reinforced concrete in the construction of bullet-proof screens at the rifle butts of Breedene, near Ostend, completed in 1910 for the Belgian War Office. The screens, ranging up to a height of 40 feet, resemble retaining walls in design, the vertical slabs being 7 inches thick, with counterforts at the back, and the whole being built up from an extended foundation slab.

In a paper contributed in 1910 to the "Annales des Travaux Publics de Belgique," Colonel Algrain discussed at length the advisability of using reinforced concrete in fortifications, pointing out the economy of material and labor assured by reinforced concrete, and urging the desirability of systematic tests with the object of determining the principles underlying the resistance of reinforced concrete to artillery fire.

During the bombardment of Rio de Janeiro in 1910 by the Brazilian battleships Minas Geraes and San Paulo, a reinforced concrete water tower was struck by several shells. One of them passed through a main column supporting the elevated reservoir, without causing any serious structural injury, and the fragments of concrete detached were replaced at small cost.

Italian investigation into the resistance of reinforced concrete to artillery fire was advocated in 1907 by the well-known engineer, Lorenzo d'Adda, at a meeting of the College of Naval Architects and Mechanical Engineers. Having cited the "marvellous resistance" of the Japanese casemates at Port Arthur, the author argued that a material so effective on land would be equally useful in protecting modern battleships. Signor d'Adda was subsequently commissioned by the Italian Naval Minister to conduct tests upon two caissons, each reproducing a panel of the Vittorio Emmanuele, one protected by steel armor plate 20 cm. and 25 cm. thick, and the other protected by reinforced concrete 70 cm. and 1 m. thick, the two forms of armoring representing equal weights of the respective materials. The tests were carried out at Muggiano, and are stated to have shown an advantage in favor of reinforced concrete under artillery fire.

Several tests of reinforced concrete targets with 12-inch and 14-inch guns have been made by the United States Government, with the object of throwing light upon the safety of the Panama Canal works in case of bombardment, and upon the general suitability of reinforced concrete for coast defences; but for obvious reasons the results of these tests are not likely to be made public.

TRENCHES AND REDOUBTS

As early as September, 1914, the German positions defending Brussels and Louvain were stated by an eye-witness to form a semi-circle of wide radius with reinforced concrete trenches, redoubts, and other works. Early in the following year, when the Germans were in possession of Lille, they began to construct reinforced concrete trenches, gun emplacements, and shelters for machine guns in the outskirts of the city. By the end of 1915 the Belgian coast between Heyst and Zeebrugge had been converted into a strong artillery position by facing the sand dunes and sea wall with reinforced concrete and mounting heavy coast defence guns behind this rampart. Later these defences were extended to Knocke, the works including numerous massive shelters and also crescent-shaped ramparts, 6 feet high, around several farms, converting the latter into miniature forts. Zeebrugge harbor well illustrates the usefulness of concrete in warfare, being protected by a crescent-shaped mole 1½ miles long by 165 feet wide, constructed of concrete blocks. Although Zeebrugge has repeatedly been attacked by British warships and aircraft the mole has suffered very little, the most serious injury being the breach reported as a result of the combined attack carried out in May last.

GUN EMPLACEMENTS

During the first year of the war the rapid advance of heavy German guns through Belgium and Northern France, and the extensive use of concrete and reinforced concrete by the enemy, awakened a good deal of inquiry as to the possible existence of gun platforms in France and other countries prepared before the outbreak of war by German secret service agents. The establishment of German residents and industrial firms in buildings commanding important strategical positions in our own country naturally led to a good deal of suspicion and to the discovery of numerous concrete and reinforced concrete structures on premises occupied by ostensibly friendly Germans; and it is quite conceivable that many apparently harmless buildings and structures were intended to serve the double purpose of making money and of helping the progress of German arms in time of need. At the same time, many of the reports circulated in this country were of the nature of "scares."

Other nations besides the Germans have been busy in the application of concrete and reinforced concrete in the war. For instance, early in 1915 the Austrians mounted some of their large guns on concrete platforms in the passes near the Italian frontier to guard against invasion, and in South Tirol masked fortresses were constructed with sliding doors of reinforced concrete, colored so as to be indistinguishable from the mountain sides. The Italians have been equally industrious, as may be judged by a recent statement of Dr. Mario Borsa that in the elaborate defences behind the Italian first lines more than 100,000 tons of Portland cement have been used.

BLOCK-HOUSES

On the Western front, the Germans have made extensive employment of reinforced concrete for the construction of block-houses. A new form of block-house was described by a correspondent writing early in 1916 from General Headquarters, as having a reinforced concrete cupola from which small shells simply skidded off. More recently, the writer has received information from an engineer now serving in the French Army that he has seen many steel cupolas blown to fragments by high-explosive shells while similar structures in reinforced concrete have survived the ordeal with comparatively little injury.

Last December, a correspondent with the French Armies said that in the Forest of Bovent the Germans had built one of their numerous reinforced concrete block-houses, known as the Tour de Bovent, with walls 3 feet thick and comprising eight observation chambers and a strongly fortified tower. Although subjected to a bombardment so terrific that all the surrounding fortifications were completely destroyed, enabling the French to capture the entire wood, the block-house remained comparatively intact. According to recent reports, the Hindenburg line is plentifully equipped with reinforced concrete redoubts and machine-gun shelters, one of the latter captured at Roeux being said to have a concrete roof 7 feet thick.

ORDINARY STRUCTURES

In addition to works executed by belligerents, many of the reinforced concrete buildings and other structures plentifully scattered over Northern France have been used by the Germans as well as by ourselves and our Allies, and have shown remarkable capacity for withstanding artillery fire. One building in particular was popularly supposed by our men to be haunted, because it remained virtually intact throughout a heavy bombardment which reduced all other buildings in the town to ruins. In another remarkable case the structure involved was an elevated reservoir measuring about 80 feet long by 40 feet wide by 12 feet deep, supported on a framework composed of thin columns over 40 feet high, with horizontal bracings. Having a flat roof at a height of nearly 55 feet, with an access staircase from the ground level, the reservoir was much appreciated by the Germans as a ready-made observation post. This reservoir, built in June, 1911, of Hennebique ferro-concrete, was destroyed as far as possible when the Germans evacuated the town on March 17 last, having successfully withstood our bombardment which destroyed all surrounding buildings. The columns were broken by explosives, allowing the reservoir proper to fall to the ground, where it remained intact save for a few cracks and holes cut in the corners where explosives had been inserted with the object of trying to damage the walls.

Some two years ago the destruction of a bridge at Soissons, over the River Aisne, afforded indisputable proof of the toughness and tenacity of reinforced concrete. The bridge comprised three arches, supported by abutments and river piers, all of that material. By the aid of explosives two of the arches were brought down, but the work of destruction was by no means complete, as the fragments held together, and by the use of gangways here and there the bridge could still be crossed on foot. The enemy were far more successful with a masonry bridge a few hundred yards away, where the main span was completely disintegrated, scarcely a vestige remaining above the water level.

The numerous incidental uses of reinforced concrete in the areas affected by the war would occupy too much space for individual description, but enough has already been said to suggest that the valuable aid afforded by the material in resisting violent attacks will not be forgotten when peace is restored to the world. This view was recently expressed by a French writer in the words: "We shall make peace as we have conducted war. With reinforced concrete we shall erect the monument of our national strength."

*Engineering Supplement of the London Times.

Distribution of Nebulæ

A DISCUSSION of a systematic search for nebulæ in Kapteyn's "Selected Areas," by E. A. Fath, is given in the *Astronomical Journal*, plates having been taken covering 139 out of the 206 regions comprising the scheme. The exposures were made with the 60-inch reflector at Mount Wilson, and each lasted one hour. A number of new nebulæ are noted, and an interesting series of conclusions as to the general distribution are given. The concentration of nebulæ near the north galactic pole is very noticeable, but there are great variations in the density of distribution. There is a complete absence of these nebulae where the Milky Way crosses the sky.

Method of Testing Magnetos

IN this method the magneto to be tested is caused to produce sparks between Pt-points in an atmosphere of nitrogen enclosed in a glass bulb, across which there also extends a resistance wire in an independent circuit. The expansion of the enclosed gas due to the heat generated by the sparks is measured by the movement of a mercury column in a U-tube, one end of which opens into the bulb at the bottom. The apparatus is calibrated by means of the resistance wire.—D. NOBILI and G. CAMPOS; *Rev. Elc.*

Unsinkable Ships*

Importance of the Factor of Stability

SOME six years ago or so a good deal was heard about the unsinkable ship. The unfortunate disaster to the Titanic, coupled with the large number of ships that have been sunk during the war, has been more than sufficient to shake the faith of any who might have had a belief in the possibility of building a ship so that she would be unsinkable. Although it was thought some few years ago that it might not be possible to build a merchant ship so that she was unsinkable, yet at the same time the opinion was held that warships, with all their complicated subdivision, would be practically unsinkable. It has now been abundantly demonstrated that warships can be sunk by mine or torpedo.

The subject of unsinkable ships is not treated generally in this article, the main purpose of which is to consider damage to ships in its relation to their ability to remain upright after receiving damage. It is, however, somewhat strange to find that there are many people at the present day who still continue to put forward all kinds of proposals for rendering ships unsinkable, and a few words on the subject may therefore not be out of place.

BUOYANCY

A ship will always remain afloat provided she has reserve of buoyancy—that is to say, so long as the weight of water that would be displaced by the total volume of the ship is greater than her weight. It will help matters to consider two extreme cases. If a solid homogeneous log is just floating in water it stands to reason that any part or parts of it can be destroyed without the remainder sinking. On the other hand, if an empty shell is just afloat in water, any break in the shell, however small, will be sufficient to cause it to sink. A ship is neither a solid log nor an empty shell, but is something between the two. A ship is a shell, inside of which are all kinds of fittings, such as the structural parts, the passenger equipment, and the cargo. Every ship floats with a certain amount of reserve buoyancy, and if at any time that reserve buoyancy is destroyed the vessel is bound to founder. In the ordinary way, if some of this reserve of buoyancy is lost, the remainder will keep the vessel afloat. It follows, therefore, that any vessel can stand a certain amount of damage without being sunk. It would be theoretically possible to fill a ship throughout with some buoyant material so that it would be almost impossible to sink her. All ships, however, are built to perform certain functions, and the space inside them is not available for the carriage of buoyant material. In the older battleships the expedient of filling certain spaces with buoyant material was actually adopted, the forward compartments of these vessels being filled in this way. It is for this reason that cargo vessels have a better chance of surviving damage than passenger vessels, since the cargo itself is, generally speaking, of buoyant material, whereas there is very little material in the passenger spaces which contribute to the buoyancy.

WATERTIGHT SUBDIVISION

As it is not possible to fill a ship with buoyant material, the next best thing is to subdivide her by watertight divisions, so that any damage received to the shell is limited in extent. There are, however, drawbacks to this expedient. Even in a warship the spaces cannot be made indefinitely small, and in a merchant ship they must of necessity be large if the vessel is to be a good commercial venture. It is put forward from time to time by inventors and others that the spaces between the frames and the beams under the decks should be filled with buoyant airtight vessels. Such an arrangement is doomed to failure from the start. If the shell of a ship receives damage either by explosion of a mine or torpedo, or from collision with another ship, any such airtight vessels would be destroyed if placed between the frames. Further, the airtight spaces that did remain intact would be of use only in the compartment or compartments which were flooded. Calculation shows that the filling of the spaces between the frames and beams would give buoyancy to the ship only to the extent of about 5 to 10 per cent. of the volume of the compartment so treated. Deductions must be made from this for the airtight compartments destroyed, as already pointed out, so that the contribution to the buoyancy of the ship would be very small.

Adequate watertight subdivision is undoubtedly the best method to adopt, but even this must be very carefully worked in conjunction with the other properties of the ship, such as heeling fore and aft and transversely. In any case, it seems out of the range of practical politics to subdivide merchant vessels adequately in this way unless, in the extreme case special vessels should be set apart for carrying passengers only to the exclusion of cargo, the cargo being carried in vessels specially adapted for the purpose, with no passengers. But even such vessels would survive only moderate damage.

The attitude now taken up by all responsible naval architects is a recognition of the fact that it is possible to sink any ship, provided the damage is extensive enough, and that the only reasonable course to pursue is to take precautions so that a vessel will not be easily sunk by moderate damage. There is one aspect of this matter, however, which does not yet appear to have received the attention is deserves. The usual method of procedure is so to subdivide a ship that, when she has received damage to a certain extent, which is usually arbitrary, she will have sufficient reserve of buoyancy to withstand it. It does not follow that this in itself is sufficient. Another important consideration is the stability of the ship when undamaged and the amount of stability she will lose on receiving damage.

CAPSIZING

Before the war all the evidence taken by the Committee appointed by the Board of Trade to consider the subdivision of ships showed no instance of merchant vessels capsizing after damage. Since then there have been numerous instances where merchant vessels have capsized. Such cases are often explained by the presence of longitudinal subdivision in the ship in addition to the ordinary transverse subdivision. When a ship has a bulkhead fitted at some little distance from the side of the ship and running practically parallel with it, it follows that if she receives damage a volume of water will be admitted to one side only, which will naturally heel her over. In the ordinary way, the stability of a merchant ship is not great enough to withstand this treatment, and she naturally capsizes.

When, however a ship has transverse subdivision only, she may still lose stability when damaged. When the side of a ship is breached an area of waterplane becomes open to the sea, and it may be of sufficient size to cause the stability to become negative, with the result that the ship heels over and possibly capsizes. It is undoubtedly true, and incidentally fortunate, that generally when the damage received is not sufficient to sink the vessel bodily her stability remains positive. Should, however, the damage be so extensive as to destroy the reserve of buoyancy, it will often happen that so much stability will be lost as to cause the vessel to heel over and sink. This causes her to founder much more quickly than if she sank bodily. If a vessel is bound to sink as a result of damage, the longer she takes to do so the more chance there is of saving the lives of those on board, and, in consequence, anything that can be done to prevent capsizing is of great value. Once a vessel begins to heel over all the openings on the side give free access of water to the interior. This rapidly increases the heeling and further reduces the reserve of buoyancy. It is next to impossible for the passengers and crew to keep their feet except at very small angles of heel, and in consequence the task of launching the ship's lifeboats becomes almost impossible. This has been exemplified in several cases recently, notably those of the Empress of Ireland and the Lusitania.

It has already been remarked that it is possible even when a vessel has transverse subdivision only that she may capsize when damaged. The provision of adequate stability in the ship when in an average loaded condition is therefore important, and should be considered in connection with the subdivision. It is somewhat remarkable to find that the loadline rules and the Bulkhead Committee's regulations make no provision for the transverse stability of vessels. This circumstance is probably accounted for by the fact that rules for this purpose would be extremely difficult to draw up. Nevertheless, it is a matter to which the designer of a ship should give particular attention, especially as every case has practically to be considered on its merits.

PASSENGER AND CARGO SHIPS

In the case of passenger steamers the water level inside the ship after she has received damage will generally be in a passenger 'tween deck, where the fittings will hardly contribute anything to the waterplane area. The loss of stability in such a case is therefore greater than with a ship mainly carrying cargo. If the water level after damage is among cargo the cargo itself will prevent the loss of a great deal of the waterplane, and accordingly the loss of stability will not be so great. This fact points to the provision of a greater amount of initial stability in passenger ships than in cargo vessels, a view which has been borne out by experience obtained during the war. Formerly it was always considered desirable for passenger vessels to have a small amount of stability in the average condition, so that they would roll easily in a seaway. Apart from other disadvantages, small stability carries with it, as will be seen from what has been said, the consequence that the safety of the vessel may be reduced. In the larger type of passenger liners it has by no means been demonstrated that a very small amount of initial stability is necessary for comfort in a seaway, and there is every reason for anticipating the provision of more stability in passenger ships in the future than there has been in the past.

The objection to longitudinal subdivision in merchant ships is that generally it causes unsymmetrical flooding and therefore capsizes the ship, but here again the question is one of the provision of adequate stability. It is quite possible to provide a ship with such a large amount of stability that even if she is fitted with longitudinal subdivision she need not capsize. It goes without saying that such a vessel would be forced to have a far greater amount of initial stability than anything that has been provided in the past. It would certainly bring with it disadvantages, but they would have to be looked upon as penalties for increased safety at sea, and as such would not necessarily be serious. At any rate, it is safe to say that the question of unsinkability of ships is closely connected with their stability, and that in the future ships will be relatively wider than the past.

*Engineering Supplement of the London Times.

Entropy of Solid Solutions

THE author gives a general theory of solid solutions based on the assumption that, in a mixed crystal, the molecules of the components are arranged in equilibrium layers with a space-lattice structure, and are able to interchange their positions by diffusion. All possible arrangements of the crystal are obtained by distributing the different kinds of molecules in all possible ways over the lattice, and each of these arrangements represents a definite chemical compound isomeric with all the others. The probability of a selected arrangement and the entropy of the solution are obtained with the help of the theory of chemical equilibrium, and this gives general formulae for the free energy and specific heat. The value of the entropy approached at high temperatures agrees with that obtained from the classical theory, but it is not zero at the absolute zero of temperature unless *one* arrangement *only* has a smaller free energy than all the others. This is the condition for Nernst's theorem (that the entropy tends to zero as the temperature decreases) to hold. If more than one arrangement has this same minimum amount of energy the Nernst theorem does not hold good.—O. STENR in *Ann. d. Phys.*

Prism with Curved Faces

On previous occasions Mr. C. Féry has, and he now describes in the *Journal de Physique* how a prism with curved faces, one of the curved faces being made reflecting, can be used in the construction of a spectrograph, how such prisms may be employed generally to give a pure spectrum, even though the incident beam is not parallel. If the beam is divergent a concave face is used for the incident light, and a convex face when a convergent beam is employed. The diacaustic of such a prism is situated on a circle, whatever the dispersive properties of the material, and this circle contains the centers of the curved faces of the prism. A description is given of the way in which prisms with curved faces may be used (i) for transforming a convergent beam into a spectral image, *e. g.*, the image of a star furnished by an astronomical objective; (ii) for the study of infrared spectra; and (iii) for the study of ultra-violet spectra. For particulars of these the original paper should be consulted.

Cytology—I

Its Methods and Their Value*

By A. Guilliermond, Chargé de Cours of the Faculty of Sciences, Lyons

CYTOLOGY has always inspired physiologists with great distrust. It is the method itself which is the subject of criticism, and for this reason all its results are regarded with suspicion.

This method consists, as we know, in *fixing* the cells, *i. e.*, by coagulating and swiftly killing their protoplasm, retaining it in the position occupied at the moment. Fixation may be regarded therefore as a coagulation, *i. e.*, as a transformation of colloidal substances without modification of apparent structure. This having been done the cell is colored by divers reagents in order to render the details of its structure more visible, and we thus succeed in obtaining a differentiation of the elements of the cell according to the affinities of the stain for one organ or another.

It is the fixation, clearly, which is the most important operation, and at the same time its weak point, since it entails a risk of altering the cell. As Policard[1] says: "There is always, in fact, properly speaking, a modification of structure, but this should not go beyond the order of the colloidal particles, and should never affect the arrangement of the higher groups which constitute for us the apparent structure. If the grouping of these particles is affected the cytologic structure is modified.

In practice it is very difficult to obtain a good fixation, and many disturbing causes may intervene. One of the most important of these consists in the intervention of osmotic phenomena. It is difficult to obtain a fixator liquid which shall be rigorously isotonic with the cellular content; therefore currents are produced between the liquid and the cellular content which cause a rupture of the meshes of the cytoplasm and a disturbance of the morphology.

To this physical cause there must be added another of a chemical nature which is doubtless of more importance than has been thought; it is that the substances employed for the fixation exert a complex chemical action upon the products of the cell; they are capable of entering into combination with them and modifying them; they may even occasion the dissolution of a part of the protoplasm, as, for example, certain essential constituents of the cell whose presence has been capable of being made evident only of recent years, thanks to special processes of fixation. The action of the fixative is moreover very little understood and the method is essentially empirical.

It is evident, therefore, that cytology, which consists essentially of reconstituting after death the various stages of cellular morphology, has a very delicate and very contestable method for its point of departure. Hence, it is easy to comprehend that physiologists have some reason for attacking this science, which rests upon a method so uncertain and so different from their own experimental method. As Chodat says, in his *Elements of Vegetable Biology:* "What a difference between the plasma of the cell thus fixed and that of the living cell! Histologic study, as conducted of late years, is that of coagulated protoplasma. It can in no wise replace the examination of living cells. It has been possible, doubtless, thus to establish more than one difference between the various coagulated protoplasm; and the methods of staining by means of which certain peculiarities of structure or certain qualities are made evident permit us to approach certain aspects of cellular chemistry and of the colloidal state; but these methods alone could teach us nothing of the structure of living protoplasm. For many years there has been an effort to throw some light upon the question of the different portions of the cellular nucleus. Without desiring to be unjust to those who have devoted their talents to this difficult problem, we may recall that we still have little precise knoweldge of the subject.

"The study of living cells and the chemistry of the nucleus has been too much neglected. The ideas obtained from the starting point of dead matter are too disputable to be regarded as an expression of reality."

Certain physiologists have even gone so far as to contest the very object of Cytology and have arrived at the conclusion that all research on cell structure effected by fixations is necessarily illusory. To every cytologist accustomed to manipulating cells it is evident that this view is exaggerated and, indeed, notably inexact. Yet it is incontestable that many of the criticisms evoked by methods of fixation are justified, and cytologists have too frequently neglected to subject their method to the proper degree of criticism.

We must admit that certain authors, *e. g.*, A. Fischer[2] and A. Mayer[3] and his collaborators have had reason in uttering warnings against the methods of fixation. But should we therefore deny to cytology that character of precision to which it lays claim? On the contrary, we shall demonstrate that, thanks to a judicious method consisting in determining the effects of fixators by a comparative study of the living cell and the fixed cell and by employing comparatively a large number of fixation processes, it is possible to obtain results which are very precise, in certain cases even as precise as those obtained in physiology.

We shall prove, too, that of recent years cytology has received a definite orientation which promises it a brilliant future.

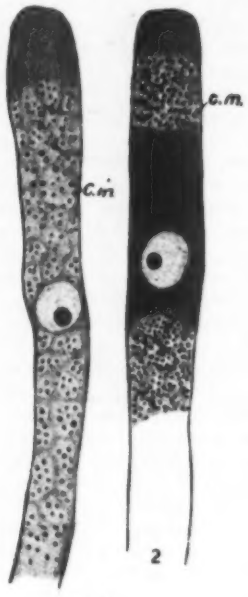


Fig. 1

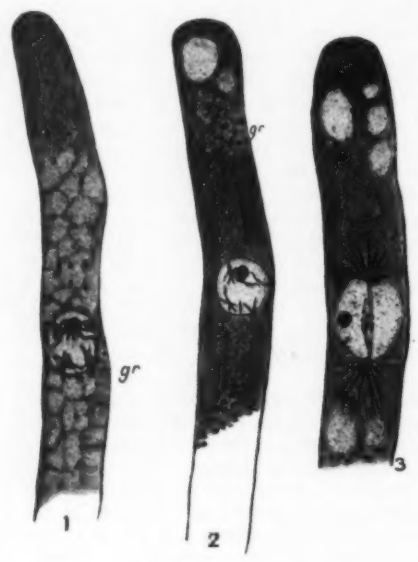


Fig. 2

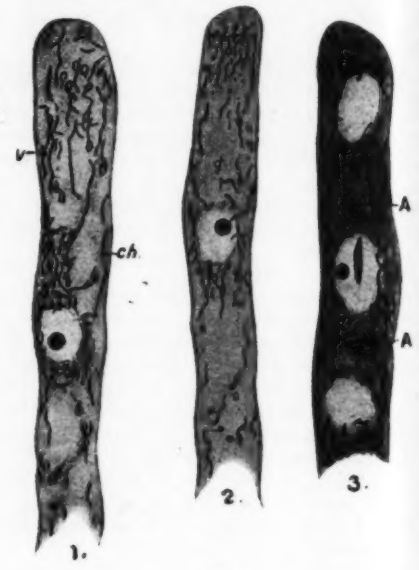


Fig. 3

Fig. 1.—Young asci of *Pustularia vesiculosa* examined after fixation with picroformolated liquid of Bouin and staining with methylene blue. The cytoplasm exhibits the alveolar structure which it had in life and the metachromatic corpuscles (*c. m.*) are well preserved and are stained a deep reddish violet.

Fig. 2.—Young asci of *Pustularia vesiculosa* after fixation with Flemming's liquid and staining with ferric hematoxylin. The fatty corpuscles (*gr.*) appear colored brown by the osmic acid. The nucleus presents remarkable distinctness of detail. In Fig. 3 (of this Fig. 2) it is in process of division (stage of equatorial disk). The metachromatic corpuscles, on the contrary, are not differentiated.

Fig. 3.—Young asci of *Pustularia vesiculosa* after fixation and staining by the mitochondrial method of Regaud. 1 and 2, stage of elaboration of reserve products. The cytoplasm is filled with mitochondria, especially chondrioconta (*ch.*), which the preceding methods did not make visible. Many form secretion vesicles (*v.*) in which reserve products are elaborated. 3, more advanced stage with unclear division (equatorial disk). The centrosomes and the chromosomes are not visible. The asters are not differentiated and are represented only by a cytoplasm minus mitochondria (*A*).

I

FIXATION

A too frequent source of error has been that investigators have confined themselves to the use of a single process of fixation, and have consequently described cells modified by the fixator, and whose modifications have not been corrected by a comparative examination of other processes and by direct observation.

There is not, in fact, any single fixative, no matter how favorable, which does not to some degree deform the cellular content. One fixative will give a good fixation of the nucleus and a bad fixation of the cytoplasm; another will have the inverse effect. An appropriate example, taken from our own investigations, will indicate the advantage of making comparative trials of a great number of fixatives in such manner as to rectify the errors which might be caused by a single one.

We select for this purpose a cell to which we have given much personal study, the ascus of a very common Pezizus, the *Pustularia vesiculosa*.[4]

In the first place, let us recall that asci are the reproductive cells of the fructifying apparatus of the Ascomycetes. This apparatus, called the *perithecium*, which in our Pezizus has the form of a cup, is constituted by a protective wall, curtained on the interior by elongated cells known as asci, each of which forms eight internal spores termed *ascospores*. At the start an ascus is a small cell with a large nucleus. This cell becomes elongated, then its nucleus undergoes three successive divisions, which result in eight nuclei. Each of these eight nuclei surrounds itself with a cytoplasmic zone, which in its turn delimits itself from the rest of the cytoplasm by a membrane and this forms a spore. The

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Revue Générale des Sciences* (Paris).

[1] Policard. The Functioning of the Kidney of the Frog *Thesis for Doctor of Sciences*, Paris, 1910.

[2] Alfred Fischer: Fixation, Staining, and Structure of Protoplasms, January 1899.

[3] A. Mayer, Rathery, and Schaeffer: On the Protoplasm of the Hepatic Cell. *Soc. de Biol.*, July 27, 1912. Action of Chromosmic Fixators on the Lipoids of the Fissures.

Mawas, Mayer, Schaeffer: Action of Certain Fixators of Nerve Cells upon the Chemical Composition of Nerve Tissue. *Soc. Biol.*, 1912.

[4] Guilliermond: Contribution to the Study of the Formation of the Epiplasm of the Ascomycetes. *Rev. Gen. de Botanique*, 1904.

spores, at first very small, gradually grow bigger at the expense of the cytoplasm which was not used in their formation. This part of the cytoplasm, which is called the epiplasm, is filled with reserve products of various nature which are utilized to nourish the spores. Finally, the epiplasm is entirely absorbed, and the spores, now grown very large, occupy by themselves the major portion of the ascus.

Let us fix by alcohol a perithecium in the course of development, and examine a section of it after having stained it. In the section we shall find asci in every stage of development, which permits us to follow the development of the cellular content of the ascus. After this fixation the young ascus presents a cytoplasm filled with an infinity of minute vacuoles, which give it a spongy aspect, and a nucleus situated in the middle of the cell. At a later stage the upper pole of the cell becomes filled with a dense cytoplasm which gradually enlarges until it fills the whole median area of the cell, whereupon the nucleus begins to divide. The eight nuclei which result from the three successive divisions remain localized in the dense cytoplasm of the median portion, and it is in this area that the eight spores delimit themselves. All the rest of the cytoplasm, *i.e.*, the spongy cytoplasm of the upper and lower areas of the cell, including the dense cytoplasm of the apical pole, constitutes the epiplasm.

We observe that the cells are greatly contracted, and that the nuclei and the cytoplasm show unmistakable signs of alteration. The cytoplasm, notably,

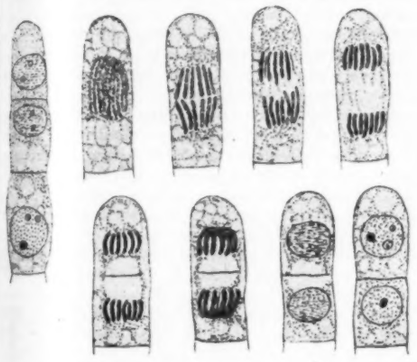


Fig. 5.—Various stages of karyokinesis in the hairs of Tradescantia virginica in a living preparation. (After Strasburger).

has a coarsely granular aspect which is not found to such a marked degree with other fixatives, and which does not correspond to what is observed in the fresh specimen. At all events, the fixation by alcohol permits us to show, after staining with the blue and violet basic tinctures of aniline, or with hematine, numerous granulations which acquire a wine-red tint with these stains, and which, by reason of this metachromasis have received the name of metachromatic corpuscles. These granulations are situated in the vacuoles of the spongy cytoplasm. The metachromatic corpuscles are reserve products which are absorbed by the spores with the epiplasm.

If we treat the cells thus fixed with a solution of iodo-iodide of potassium it will be easy to determine likewise the presence in the cytoplasm of a large quantity of glycogene, especially in the infra-nuclear area of the ascus. The other fixatives, on the contrary, preserve the glycogene much more imperfectly, or not at all, and this is one of the advantages of alcohol fixation, which in other regards is not very advisable.

By fixation with Lenhossek's liquid, (a hydro-alcoholic solution of sublimate to which has been added acetic acid) we obtain, on the contrary, a far better fixation of the *ensemble* of the cell. This does not present the contraction it exhibited after the treatment by absolute alcohol. The cytoplasm looks much less altered than in the preceding cases. Finally, the metachromatic corpuscles are brought out as clearly in the vacuoles of the spongy cytoplasm.

Bouin's liquid (aqueous solution of picric acid with the addition of formol and acetic acid) likewise allows us to obtain an excellent fixation of the cell (Fig. 1). The nucleus in particular is presented with great clearness and with no trace of deformation; on the other hand the metachromatic corpuscles lose a little of their affinity for the stains, an affinity which can be recovered, however, if the specimen is subjected to prolonged washing with alcohol.

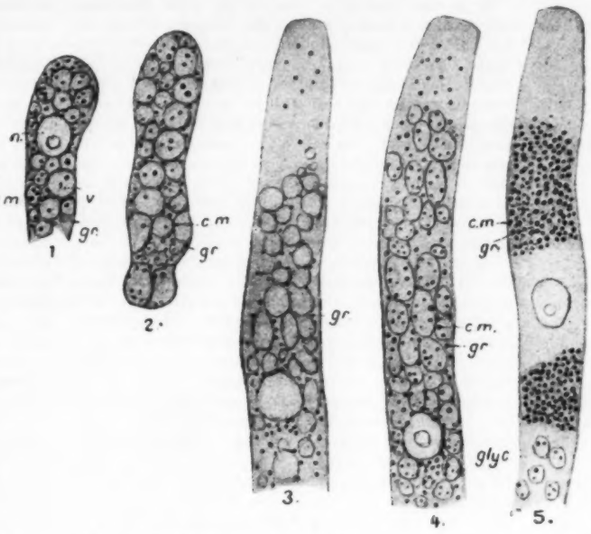


Fig. 4.—*Pustularia vesiculosa*. 1 and 2, very young asci, observed with vital coloration by neutral red. The cytoplasm is filled with vacuoles (*v.*) which enclose metachromatic corpuscles, colored by neutral red alone (*c. m.*). In the cytoplasmic network are fat corpuscles (*gr.*), uncolored and very brilliant: *n* = nucleus. 3, older ascus examined with a drop of one per cent osmic acid solution. The fats are turned brown by osmic acid. 4, the same, examined with vital coloration by neutral red. 5, still older ascus, colored by neutral red.

The use of Flemming's liquid (an aqueous mixture of chromic, acetic, and osmic acids) gives a fixation still better in many respects; it permits us to obtain better defined outlines of the nucleus and to follow with much more detail the phenomena of its division (Fig. 2). Thus it is by this method that we obtain an excellent differentiation of the *centrosomes* and the fibrilles of the asters, which do not appear very distinctly with the Bouin and Lenhossek liquids. The cytoplasm, moreover, is better preserved and has a more homogeneous aspect, which seems to more nearly approach reality. Finally, another advantage of this fixaton is that it preserves the neutral fats, which the other fixative dissolves. Hence we are able to perceive in the cytoplasm the presence of quite a large number of fatty globules, colored a deep brown by the osmic acid. The metachromatic corpuscles on the contrary, which were excellently fixed by the preceding methods, will not be differentiated after treatment by Flemming's liquid; they are not dissolved, for very attentive observation enables us to perceive their presence in the vacuoles under the form of colorless granules which are distinguishable from the vacuolar fluid by their peculiar refraction. But Flemming's liquid suppresses their affinity for the stains.

But there is more to be said: we shall see that all these fixatives, however good the results they give, none the less alter an essential part of the cell, one of the most important constituents of the cytoplasm, the *mitochondria*. These elements, which until late years had escaped the attention of the cytologists because the ordinary fixatives largely dissolve them, cannot be preserved except when the cell is fixed by what are termed mitochondrial methods. These consist in

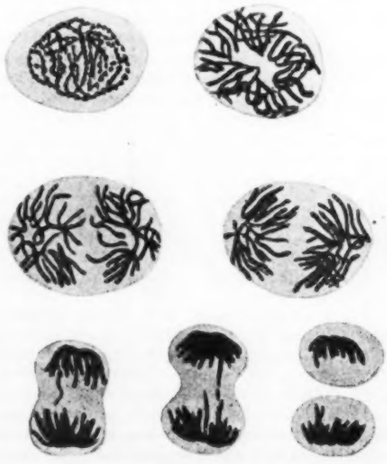


Fig. 7.—Various stages of karyokinesis in blood corpuscles of Triton, obtained by the aid of fixing and staining.

fixation by chromo-osmic mixtures, or by a mixture of bichromate of potassium and formol, followed by a prolonged stay in a 3 per cent solution of bichromate. This second operation, termed post-chromisation, seems necessary to obtain the insolubility[5] of the mitochondria with regard to the reagents which we must finally employ for inclusion in paraffine. If therefore we treat by these methods[6] a fragment of the perithecium, we shall obtain an entirely different aspect of the ascus. While with the fixations we have previously employed the cytoplasm had a confusedly granular appearance, with the mitochondrial methods it appears to be constituted by a fundamental substance but slightly chromophilous and of homogeneous aspect in which are disseminated a large number of elements strongly colored and of variable form. Some of these, the rarest, appear under the form of minute rounded granules, isolated or sometimes coupled, which resemble cocci (granular mitochomdria). The others, which are far more numerous, are rods similar to bacillæ, or with long filaments which are flexible (chondrioconta) lying in parallel order in the direction of the length of the cell (Fig. 3).

These elements, known only of late, and termed mitochondria, are found in all animal and vegetable cells and form one of the most important constituents of the cell. Every cell, therefore, includes besides its nucleus, what is called its chondriome, *i. e.*, the assemblage of mitochondria scattered throughout its cytoplasm. The researches of Regaud, A. Mayer, Schaeffer, and Fauré-Frémiet[7] tend to prove that the mitochondria are consti-

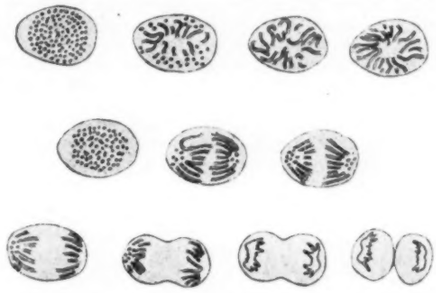


Fig. 6.—Various stages of karyokinesis in the blood corpuscles of the Triton, observed in living specimen. (After Jolly).

tuted by a lipoid substance upon an albuminoid support.

Under the influence of the alcohol or of the acetic acid which most ordinary fixators contain the lipoid substance dissolves and the mitochondria are so altered as to be no longer discernable. The biochemical researches of Mayer and Schaeffer prove, moreover, that besides the albuminoid substances, the cytoplasm always contains a notable quantity of lipoid substances, and the mitochondria seem to represent only a portion of these lipoids. The ordinary processes of fixation, therefore, dissolve this portion of the cytoplasm, which is however, very important.[8]

[5]Regaud finds that the bichromate will render soluble the lipoids, and act upon these bodies, moreover, as a mordant. Mayer, Rathery, and Schaeffer, on the contrary think that the mitochondrial methods exert an oxidizing action upon the lipoids, producing oxy-acids. A part of the lipoids will remain non-attackable, the remainder will be attacked and hydrolized. The first part comprises the oxyacids, and it is these bodies which will be colored.

[6]Guilliermond: Researches upon the Chondriome of the Fungi and the Algæ. *Rev. Gén. de Botanique*, 1915.

[7]Fauré, Frémiet, Mayer, and Schaeffer: Upon the Constitution and the rôle of the Mitochrondria. C. R. *Soc. Biol.*, 1915.

[8]Recent researches appear to demonstrate that the mitochondria are not born in the cytoplasm, but are formed only by division of pre-existing mitochondria. They transmit themselves by division, from cell to cell, and perpetuate themselves by means of the egg.

These researches have also shown the important rôle played by these elements in cellular physiology. It is demonstrated, as much by the researches of Regaud and others upon the animal cell as by our own upon the vegetable cell, that it is in the interior of the mitochondria that most of the products of the cell are elaborated.

Our own researches, as well as those of Pensa and Lewitsky, have demonstrated that the mitochondria, in differentiating themselves, give rise in plants to plastide or leucites (amylo, chloro- and, chromoplasts), in which they form amidon, chlorophyl, and various pigments.

The plastids, moreover, are on our opinion, nothing but evolutionary forms of the mitochondria, *i.e.*, mitochondria differentiated by reason of a special function. It is evident, therefore, that the plastids, which have long been known in the vegetable cell, are nothing other than special forms of very general organic bodies, common to the animal cell as well as to the vegetable cell; *i.e.*, of the mitochondria, which represent one of the essential constituents of the cell, and which are endowed with the most diverse elaborative functions.

Here, therefore, we have one of the most important elements of the cell, as essential as the nucleus, *i.e.*, the chondriome, which until now had entirely escaped observation, since none of the fixative employed had allowed it to be preserved; it can be insolubilized and put in evidence only by a prolonged treatment with bichromate of potassium. It is not necessary to believe, on the other hand, that mitochondrial methods are better for fixing cells than the ordinary methods. Far from it, since these methods nearly always notably alter the nucleus, and often do not permit the differentiation of the chromatic network.

This example, then, shows plainly that among fixation liquids there are some which are poor, altering profoundly the cellular content (*i.e.*, for certain cells, since each cell reacts in slightly different manner); while others are more favorable, seeming to preserve certain elements of the cell with as few deformations as possible; but none of them produces a good general fixation, permitting the integral preservation of the complete cell. The glycogen is well preserved only by fixatives containing alcohol. The metachromatic corpuscles have no affinity for the stains unless the specimens have been fixed by alcohol, sublimate, formol, or heat. The neutral fats are dissolved in the liquids which contain no osmic acid. The nucleus is not well preserved except by fixation with the Bouin, the Lenhossek, and, particularly, the Flemming liquid. The cytoplasm does not appear in its integrity, including its chondriome, unless the cell has been treated for a long time with potassium bichromate.

Thus we see what errors may be due to the use of fixatives without discrimination, and if the results obtained are not interpreted with very great prudence. Therefore, in making a cytologic analysis one should never be content with a single fixative. . . . It is absolutely necessary to employ a comparatively large number of fixators. . . Covergent results will give as great a degree of certitude as possible.

Since none of the fixatives gives the complete cell it is necessary, in order to form an exact idea of the latter's constitution, to establish a synthesis of the separate results obtaines by each fixator, taking into account the products which may have been dissolved by one or another. This method, finally, has the advantage of yielding information upon the chemical nature of certain elements by the manner in which they behave with the various fixatives. This is J. Renaut's method of *convergent fixations*.

The researches of A. Fischer, as also of A. Mayer and his disciples, have attempted to perfect fixation methods —hitherto too empirical. A. Mayer for example, has tried, by means of chemical analyses, before and after fixation, to determine the chemical action of fixative on the cell, and to discover according to the chemical composition of the cell, the fixatives best suited to the various components of the cell. Such attempts are of great future interest, but as yet have given results hardly appreciable.

II

VITAL OBSERVATION

The method of convergent fixation is not in itself sufficient. Its results can be only approximate and always doubtful. It is absolutely necessary to control its results, whenever possible, by the direct or vital examination of the cell.

This has been too often neglected. Moreover, the results of this vital study, because of an inexplicable prejudice due doubtless to the simplicity of the method, have often been considered as less certain than those from complex methods of fixation and staining. This is a great error, since, evidently, all such processes cause a certain amount of alteration in the cell, whereas vital observation gives incontestable results. It is true the latter is difficult to accomplish in many cases. It is scarcely applicable except to isolated cells (Algae, Protozoa, molds), to small translucent animals, or to membranous tissues. Moreover, it demands sections made by a very delicate hand, thus requiring great manual skill, or else the crushing or dissociation of tissues, manipulations which are not only delicate, but risk the destruction of the cell. Besides, and this is more important, it often happens that the very thick walls of the cell interfere with observation of the cellular content, or that the great density of the cytoplasm prevents us from distinguishing the nucleus and other elements of the cell. Finally, vital observation in no case permits so detailed a study as does fixation and staining, the power of refraction not sufficing to render the elements of the cell distinct enough. The details of the structure of the nucleus, the phenomena of its division, as well as the chondriome and other organic bodies of the cell, are rarely visible in the fresh specimen, or but imperfectly.

Vital examination, therefore, valuable as it is, ... is insufficient. With it alone Cytology would be impotent.

It is true that it is possible to color the living cell, but it is then generally the elements having the least life which take the stain, *i.e.*, the elaboration products. However there are more instances than one might think of uncolored living cells the details of whose contents can be observed with as much precision as in specimens which have been fixed and stained. In this respect the vegetable cell offers many examples. In fact it is often extremely easy to observe the epidermic cells of various vegetable organs. One need only detach with a scalpel a fragment of epidermis, which is usually not very adherent, and spread it out in a little water, or better still, in an isotomic solution of sea salt. The cells are generally very large and very favorable to vital study. By comparing the results with those of fixed and stained preparations we can thus study with great precision the action of fixatives. Moreover the study of these favorable cells permits us to observe quite plainly the nucleus and its division, as well as the mitochondria, and by analogy with what we observe in the vegetable cell we can get a much more exact idea of the structure of the animal cell, studies of which are much more difficult to realize. The minute vital study of the vegetable cell, which is both easier to observe and simpler of structure than the animal cell, is therefore of great value in Cytology. The comparison of living structures with those fixed and stained permits us to form an exact appreciation of the value of a given method of fixation and to consider the result obtained as certain if the results of both processes of observation coincide. It also permits, by analogy, the elucidation of more difficult problems of animal Cytology, and of confirming the results obtained by fixation and staining in cases where vital observation is quite impossible. There seems to be at present a reversal in cytologic method and we are returning more and more to vital examination. It is to be hoped that this tendency will be accentuated in the future.

Some examples will show us the advantages of vital examination. In choosing certain favorable examples we can demonstrate that though the criticism of fixation methods has been just, it has been exaggerated, and that there are a great many fixatives which alter its cell as little as possible and consequently yield quite certain results.

Let us take our first example, the ascus of the *Pistularia vesiculosa*. This can be observed in life without difficulty. We need merely take a thin section of a perithecium, or else crush on a slide a fragment of the soft tissue which covers the internal cavity of the perithecium. A very young ascus will appear in the fresh specimen as a very brilliant cytoplasmic cell filled with numerous minute vacuoles (Fig. 4, 1 to 5). In the middle of the cell the nucleus *n* can be discerned under the aspect of a large hyaline vesicle provided with a membrane and a nucleolus. The chromatic framework is not visible. In the cytoplasmic network we see very brilliant, small globules (*gr.*) which slowly turn brown if a drop of osmic acid solution be introduced into the preparation. These are the fat globules which fixation by Flemming's liquid enables us to preserve and makes evident. Finally, in each of the vacuoles we perceive one or several granules (*c. m.*), similar in appearance to the preceding, but distinguished by a softer, less brilliant aspect.

These granules, which are animated by Brownian movements in the interior of the vacuoles, correspond to the metachromatic corpuscles which certain methods of staining have already enabled us to perceive in fixed cells. Certain vital stains, such as neutral red and Nile blue, color these strongly, and permit us to follow their evolution even better than do fixed preparations.

At an ulterior stage, a little before the beginning of the nuclear division, the nucleus surrounds itself with a zone of dense cytoplasm, of very homogeneous aspect; which becomes more and more accentuated until it occupies the whole median portion of the cell, and which is destined to form the spores. The remainder (epiplasm) retains its spongy aspect (Figs. 4, 5), except in the apical area of the ascus where there appears a cap of dense and homogeneous cytoplasm. At this moment the whole lower portion of the cell becomes filled with a very brilliant substance, which, if we place under the cover-slide a solution of iodo-iodide of potassium, takes on the mahogany brown coloration characteristic of glycogen.

The ulterior stages enable us to observe the formation of the spores and the gradual absorption of the epiplasm and of the metachromatic corpuscles particularly.

If we refer to the structure made evident previously by the fixation and staining method we see that the spongy structure of a part of the cytoplasm and the dense aspect of the cytoplasmic area in the vicinity of the nucleus and of that which occupies the apical extremity structures which are observed after all the fixations, are found also in the living specimen: hence they may be regarded as corresponding to a real structure and we may feel assured that the fixations do not alter here the structure of the cytoplasm in its ensemble, *i. e.*, in its vacuolar system. Only the dense cytoplasm and the network of the spongy cytoplasm, instead of being granular as after the majority of the fixations, have in the fresh specimen a definitely homogeneous aspect. Moreover, the vital study enables us to follow in the living cell with or without coloration, and with much precision the evolution of the reserve products: fat, glycogen, and metachromatic corpuscles, and to prove the reality of these products of secretion. On the other hand, what the vital observation does not enable us to see is the fine structure of the nucleus (the chromatic knot) and the processes of its division; moreover, the cytoplasm, very brilliant and very dense does not permit us to observe the elements of the chondriome. Herein lies the weak point of the vital observation. Besides, in the majority of cases, the nucleus and the chondriome are very difficult to observe in the living specimen.

We shall see, by means of a certain number of examples, that happily there are to be found among animals, and especially so among plants, cells which lend themselves in a very special manner to the vital observation of the processus of nuclear division, and to the study of the chondriome. These examples demonstrate to us the reality of the mitochondrial and karyokinetic figures, which vital observation does not permit us to control in *P. vesiculosa* and which could not be made evident by fixation and staining.

The hairs of *Tradescantia virginica*, by reason of the transparency of their cells, permit us to observe with great precision their cellular content, and ever since the researches of Strasburger have been a classic subject for the vital study of karyokinetic phenomena. It is in these cells that since 1875 Strasburger[9] has been able to follow, in the living specimen, in every detail, the successive phases of karyokinesis and put an end to the disputes aroused by the discovery of this phenomenon, which was attributed by many observers to alterations due to the reagents employed.

Fig. 5, which we borrow from Strasburger, shows plainly, that all the stages are presented very distinctly.

Another analogous example, this time chosen among animal cells, is offered us by a more recent study by Jolly[10], who has also succeeded in following in the living specimen the phenomena of division in the blood corpuscles of the Triton. The comparative observations which the author has made of fixed corpuscles and living corpuscles have enabled him to affirm that the fixation liquids employed leave little to be desired from the point of view of the fixation of the chromosomes and of the karyokinetic figures. Jolly has observed in fact figures of perfect definiteness, which were exactly superposed, as in Figures 6 and 7, upon those obtained in thoroughly fixed preparations.

We owe a certain number of other vital observations of this phenomenon to Treub and to Balbiani. However, up to the present time no one has succeeded in observing in the living specimen the centrosomes and the achromatic spindle.

[TO BE CONTINUED]

[9]Strasburger: Study of Formation and Division of Cells. *Kickx*, Paris, 1876.

[10]Jolly: Experimental Researches on the Indirect Division of the Red Corpuscles, *Arch. of Micros., Anat.*, 1915.

Experiments With Pepsin to Replace Rennet in Cheese Making

IT was found that one ounce of pepsin powder (1-3000) was equivalent, in cheese making, to 12 ounces of standard rennet extract, and that it was impossible to detect any difference between cheese made with pepsin and that made with rennet. To prepare the pepsin solution for use, two pounds of common salt and three ounces of boric acid should be dissolved in one gallon of water, the solution boiled, cooled to 104° F. (40° C.), and 13½ ounces of the pepsin powder then added. —Note in *J. Soc. Chem. Ind.* on an article by D. W. STEUART in *J. Bd. Agric.*

Match Making in India

THE solution to manufacturing matches of the first quality in India lies in the use of the Himalayan silver fir and spruce. The difficulty in the way of such a proposition is extraction, as the species occur at high altitudes in the Himalayas, while many of the trees are of great size. To overcome this, it is probable that mechanical means of extraction, such as wire ropeways or light tramways, will have to be adopted, combined with the erection of portable splint-making machines in or in the vicinity of the forests, whence the splints will be exported to central places in the plains, and there made up into matches.

Fluorescence and Phosphorescence*

Their Use to Produce Luminous Effects

I. THE PRODUCTION OF FLUORESCENT AND PHOSPHORESCENT EFFECTS

By F. Harrison Glew

In general illuminants operate by incandescence, i. e., the production of light through high temperature. Other processes, not involving the action of heat, are termed luminescence, and are illustrated in a few illuminants, e. g., the mercury vapor lamps and, to some extent, in flame arcs.

To illuminating engineers the processes involved in luminescence have therefore a direct interest, apart from the wider aspects of these phenomena.

One of the most familiar examples of such effects is the firefly, the luminous efficiency of which is believed to be far higher than that of any existing illuminant, and other insects and marine forms of life have similar properties. The production of light appears to be due to chemical action. The glow of phosphorus (from which the term "phosphorescence" is derived) in the dark is due to slow oxidation, and luminosity may also be produced by the oxidation of pyrogallic acid and other organic materials. Such effects are termed "chemi-luminescence."

"Tribo-luminescence" is the term applied to luminous effects produced by friction, e. g., by rubbing or scratching certain crystals (quartz, sugar, fluorspar, etc.).

When the impact of visible light on a substance produces luminosity of a different (by "Stoke's Law" a lower order) color, this is termed "fluorescence." The effect is exhibited by fluorspar and similar crystals. When the effect still persists after the cessation of the stimulating action so that the luminosity persists in the dark, it is termed "phosphorescence." A good example of fluorescence is to be found in the transformation of violet and ultra-violet light into visible red rays by the rhodamine reflector, used with the mercury lamp to modify its spectrum. Fluorescence may be excited by other forms of radiation, for example, that emitted by an X-ray tube, or the spark from an induction coil.

Luminous paints which, after exposure to daylight, retain luminosity for some time in the dark, have been known for many years. Crystals of calcium sulphide phosphoresce blue, zinc sulphide green; other materials give a less luminous effect in yellow, red, and other colors. The manufacture of such substances and ingredients used to accentuate their action is a complex process, as qualities quite apart from chemical purity are required. For example, the form of zinc sulphide, giving the best luminous effect on exposure to daylight, may not be that most suitable for treatment to produce continuous fluorescence.

The luminous effect induced by light in these substances is transient, diminishing greatly after a few hours in darkness. At the moment immediately after strong excitation a brightness possibly exceeding one foot-candle may be shown to exist. But in a fraction of a second this initial strong effect vanishes, and although thereafter the diminution is more gradual, a brightness below that of a white surface illuminated by moonlight is soon reached, and half an hour afterwards the luminosity is very much less still. Experimental data on the degree of luminosity attainable by strong excitation by sources rich in ultra-violet rays are needed, but the measurements involved, as Mr. Blok will show, involve great difficulties.

Such phosphorescent substances have found various special applications. The strongest effect is produced with the substance in a powder, but, mixed with dilute varnish, it can be applied in the form of paint.

The most important practical results have so far been obtained with the self-luminous paints, which consist of zinc sulphide with a small admixture of radio-active constituents. Radium gives off three forms of rays—alpha, beta, and gamma—the former of which is responsible for the chief excitation of luminosity. Radium itself wastes away at a rate which will reduce it to half quantity in 1,000 years. This alone, therefore, would cause an inappreciable deterioration in luminous effect. In fact, however, self-luminous paints decay at a rate varying according to their radium constituent. A diminution of 50 per cent in brightness in the course of a year is not unusual, but much greater diminutions with a larger percentage of radium have been recorded. Half value in about twenty-four hours occurs with 74 mgrms. radium bromide per grm. of zinc sulphide, which strength I find to be equivalent to the light of the glowworm. On the other hand, the actual brightness, within limits, is roughly proportional to the radium content. It is therefore of very great importance to determine the order of brightness necessary for certain purposes, and not to exceed this required value, since any addition beyond this point adds to the expense and diminishes the life of the material. Up to the present time no satisfactory means of regenerating these materials has been found, although this is possible with some substances. The diminution in brightness, as stated above, cannot be attributed to decay of the radium component, and is believed to be due mainly to deterioration of the zinc sulphide during bombardment. In cases in which the powder is enclosed in glass, the transparency of this may also be affected by the radium in course of time, and the same applies to the varnish used as a binding material when the compound is applied in the form of luminous paint.

It is to be noted that the mixture with varnish is equivalent to dilution of the radium element; speaking generally, the brightness of material of given composition used as varnish will be about one-quarter of the value when used in the form of powder.

Such materials have many important applications in connection with the war, and the whole subject offers an opportunity for profitable research, and deserves to be more closely studied.

II. SOME APPLICATIONS OF FLUORESCENCE AND PHOSPHORESCENCE

By J. S. Dow

The subject for discussion is one on which little is generally known. These phenomena, and their relation to the complex problems underlying the production of light, are of great interest to the Society. The use of luminescence in such illuminants as the flame arc, the mercury vapor lamp, and possibly the incandescent mantle, are of interest, as suggesting the possibility of more efficient light-production than can be obtained by incandescence effects; and also because they involve free vibrations of certain wave lengths, offering the hope that eventually we may be able to control the color of light for various purposes, as easily as we now control the intensity. The firefly has long been regarded as one of the most efficient sources of light, and researches on phosphorescent substances suggest that such forms of "cold light," though relatively feeble in intensity, have almost invariably a very high luminous efficiency. Yet the experiments on this point are a little doubtful in view of the very low luminosity, and the possibly misleading effect of the physiological complexities of the eye in such circumstances. From a scientific standpoint it would be very desirable to determine the luminous efficiency of such processes with greater precision.

The effect of such substances in the dark is also of interest in view of its bearing on the matter discussed at the last meeting—the influence of glare and contrast. The visibility of these substances depends very much on the state of adaptation of the eye. A small patch of luminous paint, particularly the blue light from phosphorescent calcium sulphide, can only be seen with difficulty by an eye recently adapted to ordinary artificial light. On the other hand, in the writer's experience, the brighter forms of self-luminous paint may, to a fully dark-adapted eye, produce an effect not unlike actual glare. It is therefore very important, as Mr. Glew has suggested, to determine the minimum brightness requisite for various purposes, and not to exceed this minimum. Another effect, also clearly in evidence with the blue light of calcium sulphide, is the "spreading" of the light at distances exceeding a few feet, owing presumably to the chromatic aberration of the eye. Again, a patch subtending a small angle of the eye appears much less bright than a relatively large area, which also tends to make the surface painted fade out of sight, and, indeed, become invisible to direct vision, at a short distance away. These effects limit the application of such substances in their more feebly luminescent forms. Except when one can deal with relatively large areas, they are best suited to near vision. For the same reasons the photometry of a small area may not give the true effect of their use over a large surface.

As regards the order of brightness met with, it would appear from tests by various observers on various self-luminous paints (zinc sulphide) that the following rough rule might be tentatively suggested, namely, that the actual brightness of freshly prepared material in equivalent foot candles is rather less than one-tenth of the radium content in 1 grm. of composition. Thus 0.4 composition (i. e., material containing 0.4 mgrm. to 1 grm. of radium bromide and zinc sulphide), yields *about* 0.04 foot-candles, and 0.2 composition *about* 0.02 foot-candles (i. e., about the brightness of a white surface illuminated by full moonlight). For reasons already given, it is impossible to state such a rule with precision, but as a rough guide this may be useful. To much more powerful compositions it may not apply.

The brightness of zinc sulphide or calcium sulphide a few minutes after exposure at close range to a 50 watt electric incandescent lamp (which is typical of the type of source available to the ordinary householder) is already very much less than the "moonlight" value. From tests on some samples of the calcium sulphide "luminous buttons" now being sold for use in the dark streets, the writer has found that, after the above exposure, they were practically indistinguishable to direct vision at a distance of 10 feet, within an hour after exposure. These buttons were about 1½ inches in diameter. The brightness in such circumstances would, therefore, not be of much help in enabling people to avoid being run over by vehicles; but they might be useful in preventing collisions of pedestrians in very dark areas. On the other hand, if such material was available in large quantities for coating curbs, lampposts, etc., the larger area treated would alter the problem, and they might possibly have applications in places where there is practically no artificial light provided, or in enabling a party to keep in touch with one another when traversing a wood at night. The successful use for such devices seems at present to demand conditions of such low luminosity as practically excludes the use of artificial light. Otherwise a piece of white card may appear equally bright. On the other hand, little is known regarding the persistence of luminosity excited by sources very rich in ultra-violet light, such as the quartz tube mercury vapor lamp. After such exposure effects sufficiently permanent to be used for theatrical effects are said to have been produced. Luminous paint is also said to have been used for coating buoys and other marine objects, the luminosity induced by the sun's rays being reproduced during the dark hours of the night. In the absence of any artificial light this project seems more feasible, especially in the strong sunlight of the tropics. Luminescing materials have been found useful for many special purposes since the outbreak of war. If phosphorescing substances could be produced commercially on a large scale and at a cheap rate, new applications would doubtless present themselves (for example in underground passages and mines, for luminous danger signs and other notices, etc., and for advertisements and spectacular purposes). In small quantities their successful use seems to demand frequent excitation by sources rich in ultra-violet rays. The writer has tried coating switches with calcium sulphide, but the relatively low general illumination in an ordinary interior is not as a rule enough to produce a useful effect.

On the other hand, the self-luminous materials, continuously excited by radium, have already many important special applications. The chief present limitations to their wider use are scarcity of supply and expense. It has, however, been recently calculated by a writer in the *Electrical World* that the weaker and less expensive forms of such materials could be used for coating switches at a cost of only 1d.—1½d. per switch.

*Introduction to a Discussion at a Meeting of the Illuminating Engineering Society, held at the Royal Society of Arts, March 22, 1917. Reported in the *Chemical News*.

III. THE PHOTOMETRY OF LUMINESCENT SUBSTANCES

By Arthur Blok

The measurement of the brightness of fluorescent and phosphorescent substances is rendered difficult by two factors—(i.) the color of the light, the spectrum of which usually consists of bands or lines situated mainly in the green or blue; and (ii.) the relatively low luminosity. Both of these factors tend to introduce the Purkinje effect. Fortunately, the chief data required are usually relative, and one can thus work throughout with a colored screen placed in front of a comparison lamp, and designed to give a color which more or less matches the light of the material tested. If one wishes to obtain absolute values of brightness, allowance must be made for the absorption of the screen; but the procedure for affecting this introduces all the physiological difficulties attendant on heterochromatic photometry at low illuminations. An approximate color match may be obtained fairly easily, for example, by the use of signal green glass in testing phosphorescent zinc sulphide, but unless the spectral composition of the two lights compared is substantially identical, errors may be introduced by the order of luminosity at which the test is made, the part of the retina upon which the image is received, and, perhaps, also, by the size of the photometric surface employed.

Various photometric methods have been devised for dealing with this class of substances, and in these a color-matching screen is almost always employed. In the method described by N. E. Dorsey (*Bull. Wash. Acad. Science*, Jan. 4, 1917), a lamp is moved back and forth behind a translucent screen forming one end of a box, and the luminous compound under test is mounted on the outer surface of the screen, either in the form of paint on a card slip or in powder form in a thin-walled glass tube. Identity of color is produced by a color filter placed inside the box between the lamp and the screen. With this arrangement, the tested sample appears as a luminous island in a surrounding sea formed by the variably illuminated screen, and provided that a sharp line of demarcation can be obtained between the island and sea, there is much to recommend this plan—immediate contiguity of the two luminous areas under comparison greatly facilitates the determination of photometric balance.

In the method used at the National Physical Laboratory for comparing the luminosity of painted dials, a stencil replica of the dial under test is uniformly illuminated from behind by means of a glow lamp and a color screen. The stencilled and actual dials are mounted side by side, and by means of a variable resistance the candle-power of the lamp is brought to such a value that the luminosities of the stencilled figures and those on the actual dial are the same. By an independent calibration with a surface brightness photometer, the brightness of the stencil for any resistance setting is known. Here, the mean effect over the whole of the surfaces viewed is judged, and as long as the dials are small there should be little difficulty in doing this. But if the dials are large, the various figures will be at different distances from the eye, and it would appear that trouble may be introduced on that account. The method, however, has the advantage that by enabling finished dials to be dealt with in their entirety it gives a final comparison of their merits, whereas if small samples of paint are measured there is always the possibility that variations in the finished article may be introduced during the painting operation, for example, by irregular mixing or uneven application of the paint.

In another scheme, developed by Prof. Clinton and Mr. Dow for measuring some very small samples in association with the speaker, the sample is viewed at a constant distance from the eye through a small opening in a white screen placed at an angle of 45° to the line of sight and to the axis of the photometer bench (the line of sight being normal to the bench axis). The opening is of such a size as to be completely filled by the luminous specimen fixed behind it—i. e., the "island and sea" plan is adopted. The inverse square of the distance of the lamp from the screen at photometric balance is proportional to the luminosity of the sample.

A point to be borne in mind in speaking of the photometric values of self-luminescent substances is that the luminosity of the material in powder form is considerably higher than when the material is mixed with varnish or other substance to form a paint. Moreover, the thickness of the layer tested to some extent determines the foot-candle value. A further factor which may influence the result in the treatment of the substance in regard to exposure to light before the test. In the case of substances like Balmain's compound, this is obviously a matter of prime importance, but with materials depending on radio-active excitants for their luminosity, the effect of previous light action is, as far as the speaker is aware, not yet thoroughly known. Indeed, it is very evident that for the systematic specifications of these self-luminous substances standard test conditions still remain to be worked out.

For some purposes a single photometric measurement on any of these materials may suffice, but usually it is equally important to know the rate of luminous decay with the lapse of time. It is somewhat remarkable that although the chemical and physical sides of radio-activity and phosphorescence have been brought to a very advanced stage, very little appears to have been published on the luminous values of the substances now under discussion, and one looks almost in vain for data on the practical matter of variation of foot-candle values with time for a compound of a given nature. The present activity in night operations in war has caused a very great demand for self-luminous compounds, and, no doubt, the results of tests extending over moderately long periods will be available presently. Such tests require very great care, for at best the initial luminosities under measurement are small, and after some time they sink to values that are very difficult indeed to measure, at any rate by the eye, which after all is the instrument with which the substances are used in practice. The products now used commercially have brightnesses of the order of a few hundredths of a foot-candle, and give nearly monochromatic lights. These are conditions that tax the photometrist, and the repetition of observations to 5 or 6 per cent in tests of this nature would indicate very good work.

On the whole, there seems to be a large field for the application of photometric methods in the investigation of these substances. The subject of self-luminescent materials is at the interesting stage where practical applications are emerging, and those who are conversant with the better known applications of photometry in lighting work generally might well devote attention to the investigation of the luminous phenomena exhibited by the class of bodies now being discussed.

Artificial Silk

BECAUSE artificial silk consists mainly of cellulose hydrate and this substance swells up when treated with water, such silks are found to suffer from moisture and thus lose their strength, so that they cannot be relied on to produce any very durable goods. On the other hand it is not an easy matter to proceed with the dyeing of artificial silk in the shape of skeins, for the fiber becomes dissolved or disintegrated in the bath unless great care is taken. Various patents have been obtained for strengthening of artificial silk, and among these the Eschalier method treats the silk with formaldehyde and other substances under pressure or in a vacuum. What is known as the "stenosage" process gives double the strength to silk in the wet state. The precise chemical action in this latter case is a subject of discussion. However, the latter strengthening method appears to make the silk less apt to take dyes, so that it is different to carry on the dyeing process, and most of such material is dyed in black. On the whole, the matter is one in which there is considerable room for improvement, and this is a promising field for inventors.

Permanence of Color Plates

ONE of the points that remained to be studied in connection with autochrome or natural color photographic plates was the permanence of the colors. As is well known, the different minute elements of the plates are composed of grains of potato starch which absorb the various colors, and from the fact that aniline colors are employed here, it might be supposed that the colors were likely to fade out easily under a long exposure to the action of light. However, it should be remarked that it is a common error to suppose that colors which are known as artificial, and which are called aniline colors though often wrongly, are not of a permanent nature, for a great number of them are in fact as permanent as many natural colors. As regards the color plates, of course, the only method to test this is to actually expose the plates to the action of light for a considerable time. Experiments were made in France in 1908-1911 by M. De Gaudemaris, with various exposures of which the longest was 52 months (northern exposure), and he found that the colors had altered considerably. Green was the most permanent and violet the least, with the other colors intermediate. But more recent researches made by V. Cremier show contrary results. Exposure was made at Marseilles from June to September and thus to a very bright light, usually in sunlight. After four months' exposure he found no change whatever in the color compared to a test plate kept in the dark, and this result is a striking one, taking into account the value of the light in this region. Compared with the above, it is to be noted that the former test was made upon plates prepared in the early stages of the art, which employed different chemical baths from what are now used in the more perfected state of the art. It should be added that the same plate was exposed to the light of an incandescent gas burner for one to four hours a day during a period of 30 months, thus not only to the light but also to the heat of the burner, but no change in color was produced. Considering that the color plates are principally used for lantern or stereoscopic work, it will be seen that a plate of this kind is likely to hold its color indefinitely.

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